Summary of Stream Habitat Inventories on the Blue Ridge and Chattooga River Districts of the Chattahoochee National Forest, Georgia 2015

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Research Center Drive
Blacksburg, VA 24060-6349

C. Andrew Dolloff, Team Leader

Report prepared by:
Colin Krause[1], Craig Roghair[1], and Michael Joyce[2]
May 2016

[1]USDA Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Research Center Dr.
Blacksburg, VA 24060

[2]USDA Forest Service
Chattahoochee-Oconee NF
1755 Cleveland Highway
Gainesville GA 30501

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Introduction

Past land management practices including logging and road building, have left many streams on the Chattahoochee-Oconee National Forest (CONF), Georgia with a legacy of degraded habitat, including long shallow riffles, few pools, large deposits of sediment, and decreased amounts of large wood (Waters 1995). Both native (Brook Trout, *Salvelinus fontinalis*) and naturalized (Brown Trout, *Salmo trutta*; Rainbow Trout, *Oncorhynchus mykiss*) trout populations on the CONF are impacted by these conditions. If other limiting factors (water temperature and chemistry, exploitation, etc.) remain the same or improve, habitat restoration including the control of excess sediment inputs and the transport and addition of large wood will likely increase the likelihood of trout persistence or recovery.

Trout populations can be impeded by lack of deep pools, high amounts of fine sediment, and insufficient amounts of large wood necessary to create and maintain complex habitat. Wood of all sizes is an important feature of streams flowing through forested areas. In particular, large wood (LW) and other obstructions such as boulders slow flow, trap sediments, and damp and delay flood peaks (Montgomery et al. 2003). Tree boles (i.e. tree trunks or rootwads) are major pool forming elements and wood contributes to aquatic habitat in diverse ways such as providing cover from predators, refuge from high velocity flow, as well as the LW being the substrate and organic matter for macroinvertebrates (Benke and Wallace 2003, Dolloff and Warren 2003). Large wood is considered so beneficial that riparian forests today are managed for LW inputs (Boyer et al. 2003, Jacobs 2004) and where recruitment or loading is judged insufficient, LW is intentionally added to stream channels (Reich et al. 2003).

Wood naturally enters stream channels by various avenues including bank undermining or blowdown of individual trees or groups of trees and transport en masse in debris flows or landslides from upstream channels or adjacent riparian areas (Swanson 2003). Although logging was one of the more dramatic causes for the decline in large wood loading, other human influences such as the construction of roads and trails and land clearing in general have influenced both the rate and amount of large wood entering streams (Nakamura and Swanson 2003). Invasive species can also lead to variation in the rate of LW recruitment. Since the beginning of the 20th century a fungus, inadvertently brought to North America on nursery stock from Asia, has killed nearly all American chestnut (*Castanea dentata*) trees. American chestnut was a dominant tree throughout much of the eastern US where, except for areas of salvage, its demise resulted in higher than expected rates of large wood and large wood recruitment to streams and riparian areas.

Today, hemlock wooly adelgid (*Adelges tsugae*), an aphid-like insect from East Asia threatens another keystone species of eastern forests, eastern hemlock (*Tsuga canadensis*) with a similar fate. Eastern hemlock trees in the CONF watersheds are infested by the hemlock wooly adelgid resulting in a rapid decline of hemlock trees, a major component of streamside vegetation. With seedling hemlock trees unable to reach maturity in the presence of hemlock wooly adelgid, dead hemlock trees located in riparian areas are a temporary source of large wood for these streams. Dead or dying hemlocks may be allowed to recruit through natural processes, or may be intentionally added to stream channels.

Large wood additions encourage pool formation and sediment scour, thereby increasing the amount of spawning and rearing habitat, particularly for trout (Ryan et al. 2014, Faustini and Jones 2003, Thompson 1995). Habitat assessments are needed to optimize the effectiveness of habitat remediation projects. The CONF partnered with the USDA Forest Service, Southern Research Station, Center for Aquatic Technology Transfer (CATT) to complete stream habitat inventories in the Blue Ridge District and Chattooga River District of the CONF in 2014 and 2015 (Figure 1). Our goals were to: 1) quantify current stream habitat conditions; and 2) describe Hemlock abundance and condition within the riparian area. The CATT deployed a 6-person crew to the CONF in summer 2014, and a 7-person crew to the CONF in summer 2015 to inventory stream habitat and describe hemlock abundance and condition. Results of our 2014 surveys are presented in Krause et al. (2015). Here we present the results of our summer 2015 surveys.

Methods

Site Selections and Reach Layout

Mike Joyce (CONF Forest Fish Biologist), CONF District Biologists, and personnel from the Georgia Department of Natural Resources collaboratively selected stream reaches for inventory. The majority of reaches were chosen because they could be the target of future stream habitat improvement work if habitat inventories indicate such improvements are necessary and achievable. Cooper Creek was by far the largest of the streams selected for inventory. It is listed as impaired (i.e. the fish bioassessment resulted in an IBI ranking of “poor” or “very poor”) under section 303(d) of the Clean Water Act. Both Cooper Creek and Burnett Creek are in close proximity to proposed vegetation management projects.

Habitat Inventory

We performed basinwide visual estimation technique (BVET) habitat inventories on 7 of the 12 streams visited that did not have access or flooding issues (Figure 1, Table 1) (Dolloff et al. 1993). The BVET is a two-stage visual estimation technique used to quantify stream habitat. During the first stage, habitats are classified based on naturally occurring habitat features as pools (slow water, surface turbulence may or may not be present, gradient <1%; generally deeper and wider than habitat immediately upstream and downstream, concave bottom profile), or riffles (fast water, turbulent, gradient <12%; shallow reaches characterized by water flowing over or around rough bed materials that break the surface during low flows). Glides (slow water, no surface turbulence, gradient <1%; shallow with little to no flow and flat bottom profile) were identified during the inventory, but were grouped with pools for some data analysis. Runs (fast water, non-turbulent, gradient <12%; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile) and cascades (fast water, turbulent, gradient >12%; highly turbulent series of short falls and small scour basins, with very rapid water movement) were grouped with riffles for some data analysis.

Habitat in each section of stream was classified and inventoried by a 2 or 3 person crew. One crew member identified each habitat unit by type (as described above), estimated average wetted width, average and maximum depth, riffle crest depth (RCD), substrate composition, and percent fines. The length of each habitat unit was measured with a hip chain. Average wetted width was visually estimated. Average and maximum depth of each habitat unit were estimated by taking depth measurements at various places across the channel profile with a graduated staff marked in 5 cm increments. The RCD was estimated by measuring water depth at the deepest point in the hydraulic control between riffles and pools. The RCD was subtracted from average pool depth to obtain an estimate of residual pool depth. Substrates were assigned to one of nine size classes (Appendix A). Dominant substrate (covered greatest amount of surface area in habitat unit) and subdominant substrate (covered 2nd greatest amount of surface area in habitat unit) were visually estimated. Percent fines is the percent surface area of the stream bed consisting of sand, silt, or clay substrate particles (particles < 2 mm diameter).

Where encountered, the distance at the upstream end of channel features, as well as additional attributes described in Appendix A, were recorded for waterfalls, tributaries, side-channels, braids, seeps, landslides, and 'other' miscellaneous features encountered (e.g. campsites, fish habitat structures, etc.). In addition, a photograph and GPS ID (as well as additional attributes described in Appendix A) were recorded for waterfalls and crossing features (bridges, fords, dams, and culverts).

The second crew member classified and inventoried large wood (LW) within the bankfull channel and recorded all data. LW was assigned to one of four size classes (Appendix A). All wood less than 1.0 m long and less than 10 cm in diameter were omitted from the inventory.

The first unit of each habitat type selected for intensive (second stage) sampling (e.g. accurate measurement of wetted width) was determined randomly. Additional units were selected systematically (every 10th habitat unit type for streams >1000 m and every 5th habitat unit type for streams <500 m). The wetted width of each systematically selected habitat unit was measured with a meter tape across at least three transects and averaged. For the reach between each second stage fast water habitat unit, we estimated the abundance and condition of Hemlock trees within the riparian area (Appendix A).

The ratio of measured to visually estimated area was used to calibrate all estimates, which enabled the calculation of total stream area by habitat type (Hankin and Reeves 1988). The BVET calculations were computed with a Microsoft Excel spreadsheet using formulas found in Dolloff et al. (1993). Data were summarized using Excel spreadsheets. See Appendix A for detailed field methods.

Results

From July 7-14th 2015 we inventoried 7 streams totaling 27.7 km of stream habitat on the CONF (Figure 1-5, Table 1). GPS coordinates for the start and end location of the inventories, are available in Table 2.

Depth and Width

Mean residual pool depth (the riffle crest depth was subtracted from average pool depth to obtain an estimate of residual pool depth which could occur during low flow conditions) ranged from 14 cm to 41 cm among the inventoried streams (Table 3). All streams tended to have deeper maximum pool depths in the downstream reaches than in upstream reaches; the exception being Cooper Creek, a larger stream where the inventory ended at the confluence with Burnett Creek prior to reaching the upper watershed (Figure 6). The average wetted pool width ranged from 3.0 m for Burnett Creek to 11.0 m for Cooper Creek, followed by 7.2 m for Persimmon Creek (Table 3). The average wetted riffle width ranged from 3.4 m for Burnett Creek up to 14.4 m for Cooper Creek, followed by 5.4 m and 5.3 m for Bear Den Creek and Charlies Creek respectively (Table 3).

Habitat Area

All inventoried streams had low percent slow water (pools + glides) habitat area (9-26%) (Figure 7, Table 4). Fast water (riffle + run + cascade) habitat made up the majority (73-91%) of the stream area and was highest (91%) in Cooper Creek (Figure 7, Table 4). Though the majority of the habitat area is fast water habitat (a result of larger unit size), the quantity (i.e. unit count) of slow water units (pool and glide) to fast water units (riffle, run, cascade) was similar for all streams (Table 4). Long Creek, Dicks Creek, and Persimmon Creek had the highest percentage of pool habitat area (18%, 17%, and 18% respectively) (Figure 7, Table 4). Cascade habitat area was highest for Persimmon Creek (8%) and Long Creek (6%) (Figure 7, Table 4).

% Fines and Substrate

The average percent fines (percent of habitat unit's channel bottom covered by sand, silt, or clay) in pools of the inventoried streams was 30% to 77% (Table 3). Though percent fines in riffles were less, one stream still had up to 39% fines (Burnett Creek) while others were >20% (Long, Dicks, and Persimmon Creeks) (Table 3). There were no apparent longitudinal trends in percent fines (Figure 8).

In pools, the dominant substrate was most frequently sand and bedrock; the substrate types organic matter, silt, small gravel, large gravel, cobble, and boulder were also present, but typically as a subdominant substrate (Table 5, Figure 9). In riffles, the dominant substrate was most frequently cobble and bedrock; the substrate types organic matter, sand, small gravel, large gravel, and boulder were also present, but most often as a subdominant substrate (Table 5, Figure 10). In Long Creek's riffles there is a change in substrate type with distance upstream; transitioning from cobble, boulder, and bedrock to large gravel and sand at ~2,000 m (Figure 10).

Large Wood

The total pieces of large wood per kilometer (LW/km) ranged from 81 in Dicks Creek to 155 in Burnett Creek (Figure 11, Table 6). The majority of LW was small diameter size classes (10-55 cm diameter) (Figure 11, Table 6). Persimmon Creek had the largest amount (6 LW4/km) of size class 4 (>5 m length, >55 cm diameter) (Figure 11, Table 6). Large wood is distributed fairly evenly throughout the inventoried reaches; there are occurrences of log jams resulting in higher wood counts within an individual habitat unit (Figure 12).

Hemlock Abundance and Condition

Hemlocks were present in the riparian area of all streams and showed varying degrees of infestation with Hemlock Wooly Adelgid (Figure 13). The following streams had high (>50) hemlock abundance for the majority of the inventoried reach: Cooper Creek, Charlies Creek, Dicks Creek, and Persimmon Creek (Figure 13). The following streams had long reaches where dead Hemlocks were present: Charlies Creek, Dicks Creek, and Persimmon Creek (Figure 13). Hemlock data was not collected on Bear Den Creek due to flooding that ended the inventory early.

Discussion

Habitats in the inventoried streams show the typical degraded legacy of late 19th-early 20th century land use. Many have long and shallow riffles, shallow residual pool depths, high percent fines, and low amounts of LW in the most desirable large size classes. Many also contain fish habitat improvement structures designed to increase habitat complexity by creating pool habitat and cover for fish, as well as to trap spawning gravel and flush out fine sediments (Seehorn 1992). Streams inventoried in 2014 (Krause et al. 2015) and 2015 had similar habitat conditions; stream area comprised mainly of fast water habitat, high percent fines in slow water habitat, very little large diameter large wood, and hemlocks are predominantly infested and dead within the riparian area.

The large-scale loss of hemlocks from hemlock wooly adelgid infestations, though tragic, also presents a new opportunity as the CONF continues to address the impacts on the Forest from historical land use. The riparian areas of all the inventoried streams contain hemlock trees infested with hemlock wooly adelgid. Over time some of these hemlocks will shed limbs and tops, while others will fall entirely into the stream channel, providing a variety of LW sizes. Hemlocks can also be deliberately felled into stream channels to strategically provide additional channel complexity in high-priority management areas. All the inventoried streams had ≤155 LW/km and all were largely lacking in wood of the largest size class (LW4).

Given the high number of dead or dying hemlocks, these streams are prime targets for LW treatments, but how much wood is enough? Neighboring National Forests in South Carolina and North Carolina specify that the desired LW condition is 322 and 161 LW/Km, respectively (USDA 1994 and 2004b). The CONF does not specify a LW/Km target, but they do manage streams and riparian areas to maintain, enhance, and recruit LW (USDS 2004a). Researchers have not found an upper limit on the amount of large wood that is beneficial to fish so most often the upper limit will be determined by social factors rather than fish habitat objectives (Richards and Hollingsworth 2000), particularly in areas managed for multiple uses.

Sand was prevalent as both a dominant and subdominant substrate in many of the streams, as is evident by the high percent fines (sand and silt exceeding 35%) observed in most pools. Researchers have demonstrated that when fines exceed 35% trout reproduction is negatively impacted (Everest et al. 1987). Fines can be reduced in spawning gravel by salmonids building redds, flushing flows from storm events, and large wood improving stream habitat though pool creation and habitat complexity. Newly formed plunge pools from LW can help flush out fine sediments and expose additional patches of spawning gravel (Ryan et al. 2014, Faustini and Jones 2003, Thompson 1995).

Land management practices such as wholesale logging in the watershed in the early 1900's are still impacting the number and size of trees available, as well as sediment inputs. Efforts to reverse or mitigate habitat degradation effects have been ongoing for decades and will continue into the foreseeable future. In the long run, it will prove cost-effective to manage riparian areas to provide a source of LW for natural recruitment. Efforts to enhance habitat by adding designed structures has resulted in improved habitat conditions, however many of these structures are reaching the end of their designed lifespan. Clearly, decisions made by today's land managers will impact large wood recruitment and retention, and sediment transport and deposition, for decades to come. New challenges may present new opportunities and we encourage the CONF and its partners to continue their work to improve stream habitat.

Data Availability

Summer 2015 and 2014 stream habitat data reside in a MS Access database, which is managed by the CATT, and a copy has been provided to Mike Joyce, CONF Forest Fish Biologist. We will work with the CONF to develop custom queries and reports for the MS Access database, as needed.

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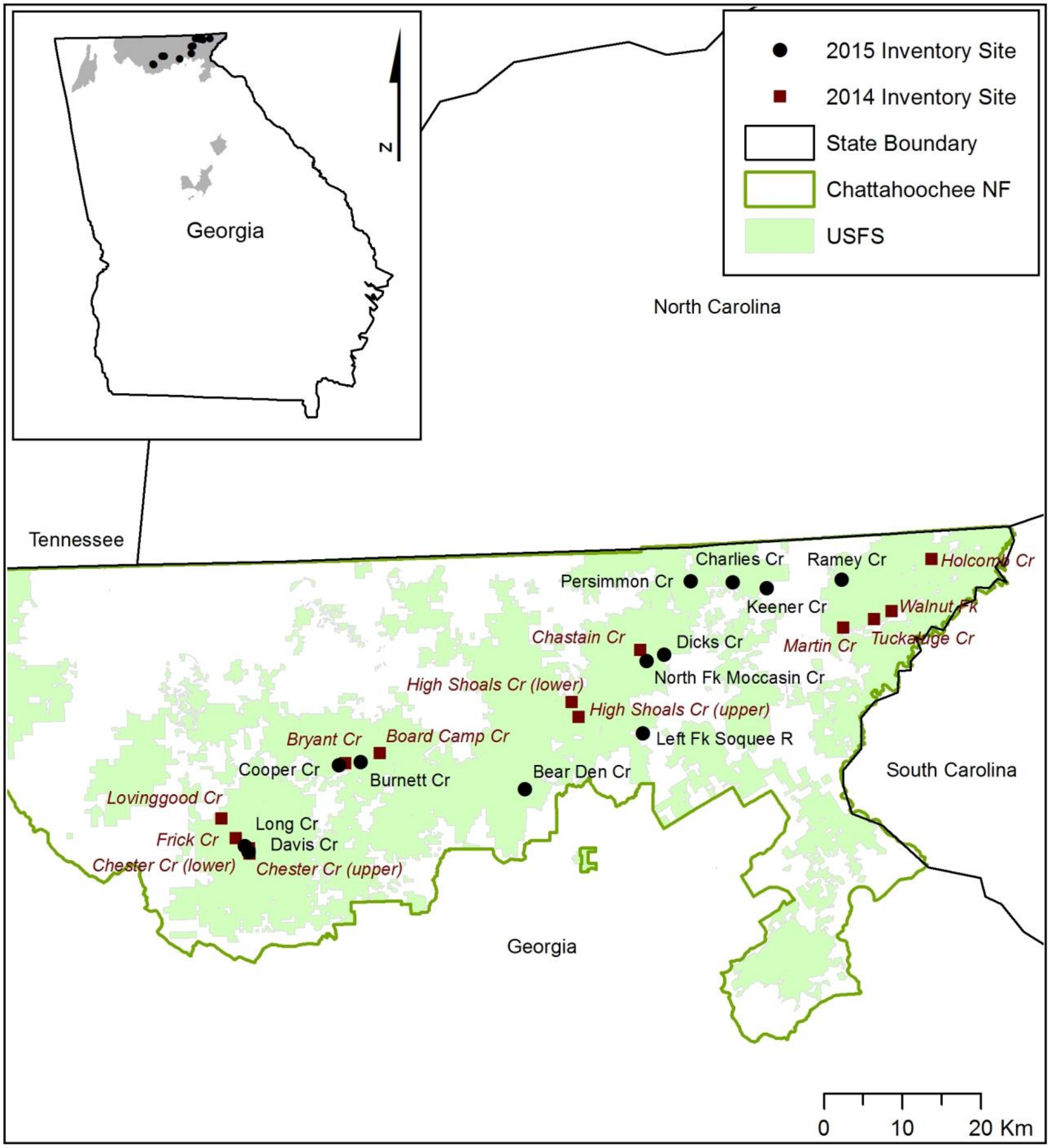


Figure 1. Streams visited on the Chattahoochee National Forest, Georgia, 2015, as well as previously in 2014 (Krause et al. 2015).

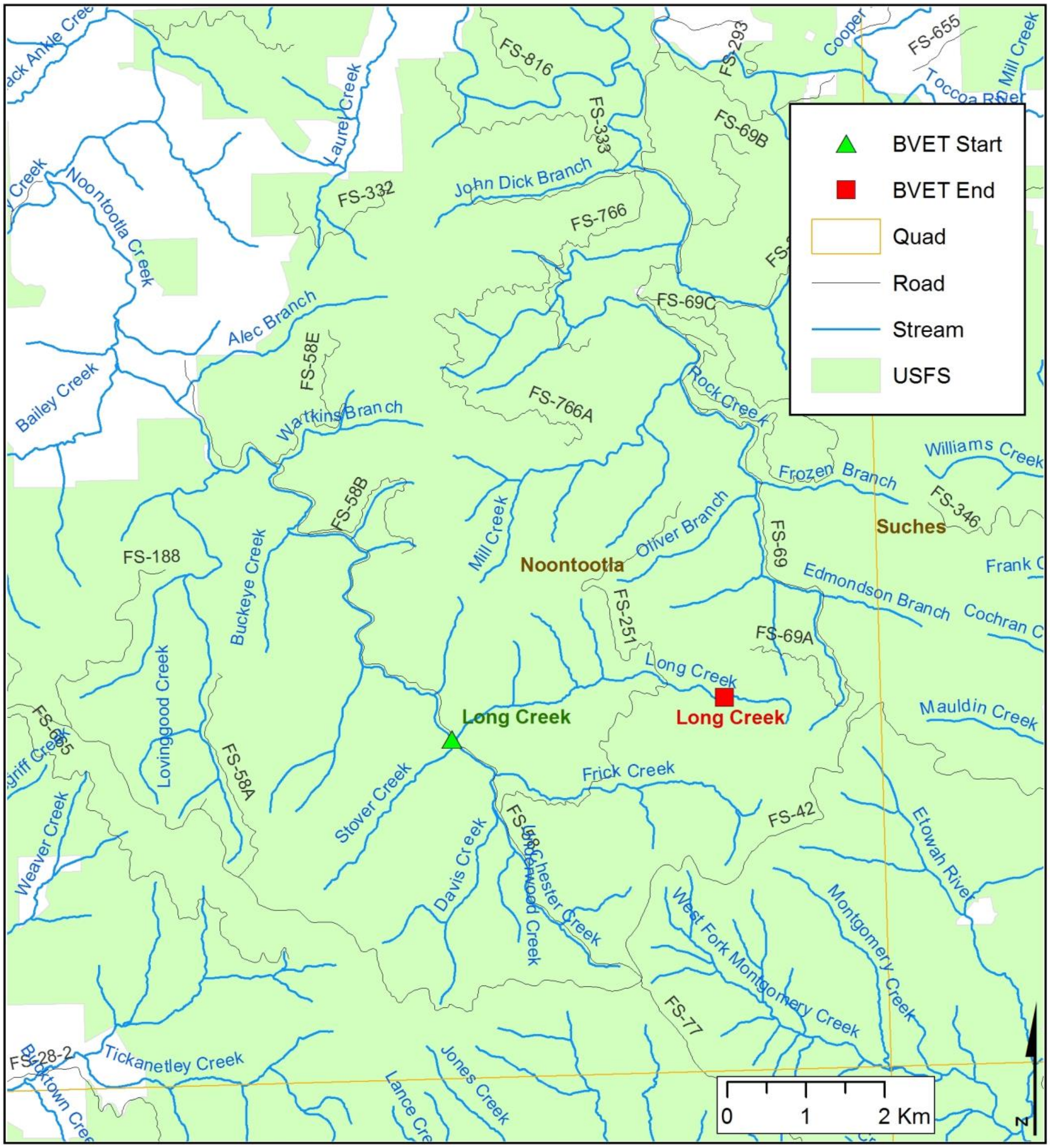


Figure 2. BVET inventory start and end location on Long Creek on the Chattahoochee National Forest, Georgia.

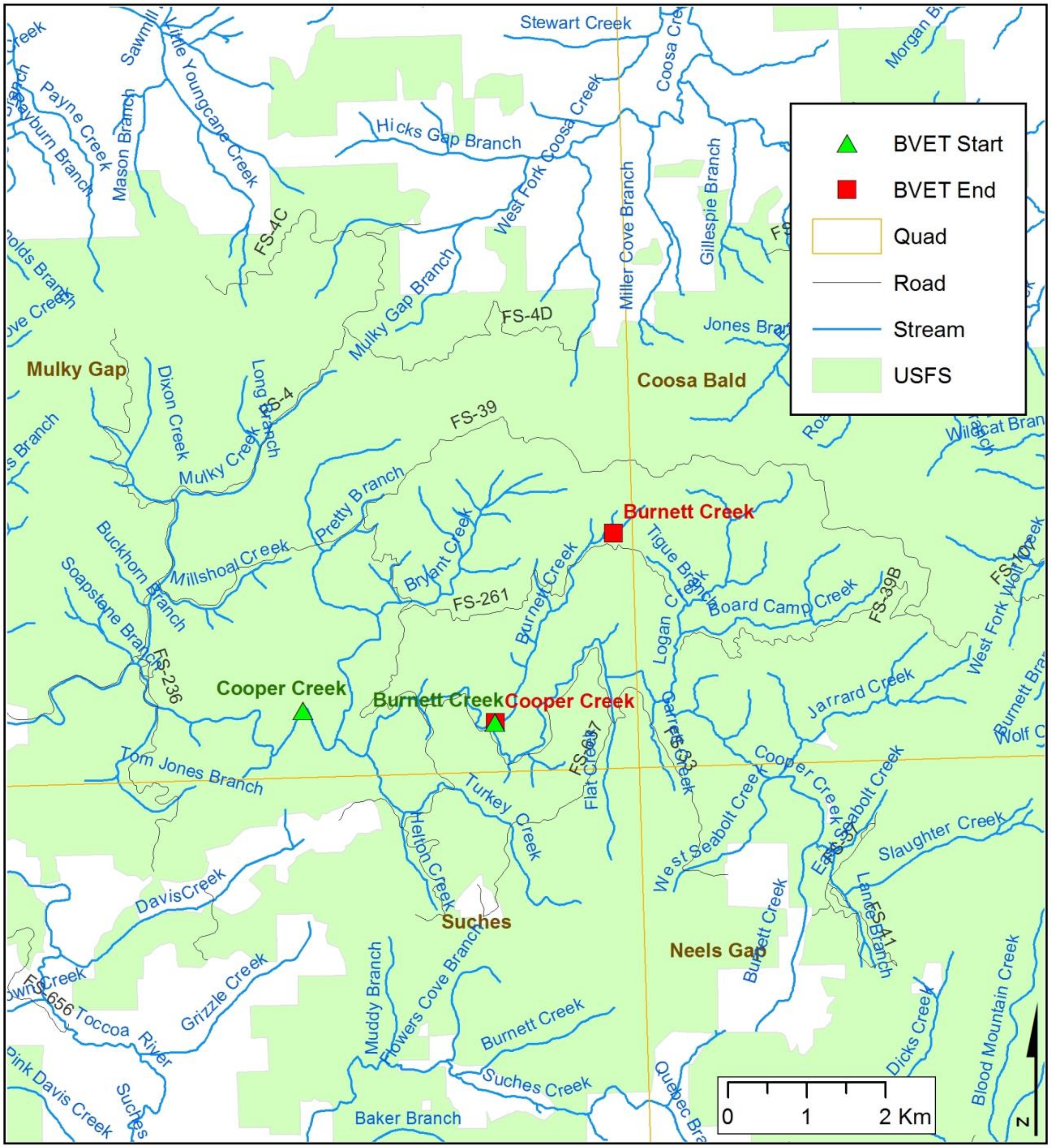


Figure 3. BVET inventory start and end locations on Cooper Creek and Burnett Creek on the Chattahoochee National Forest, Georgia.

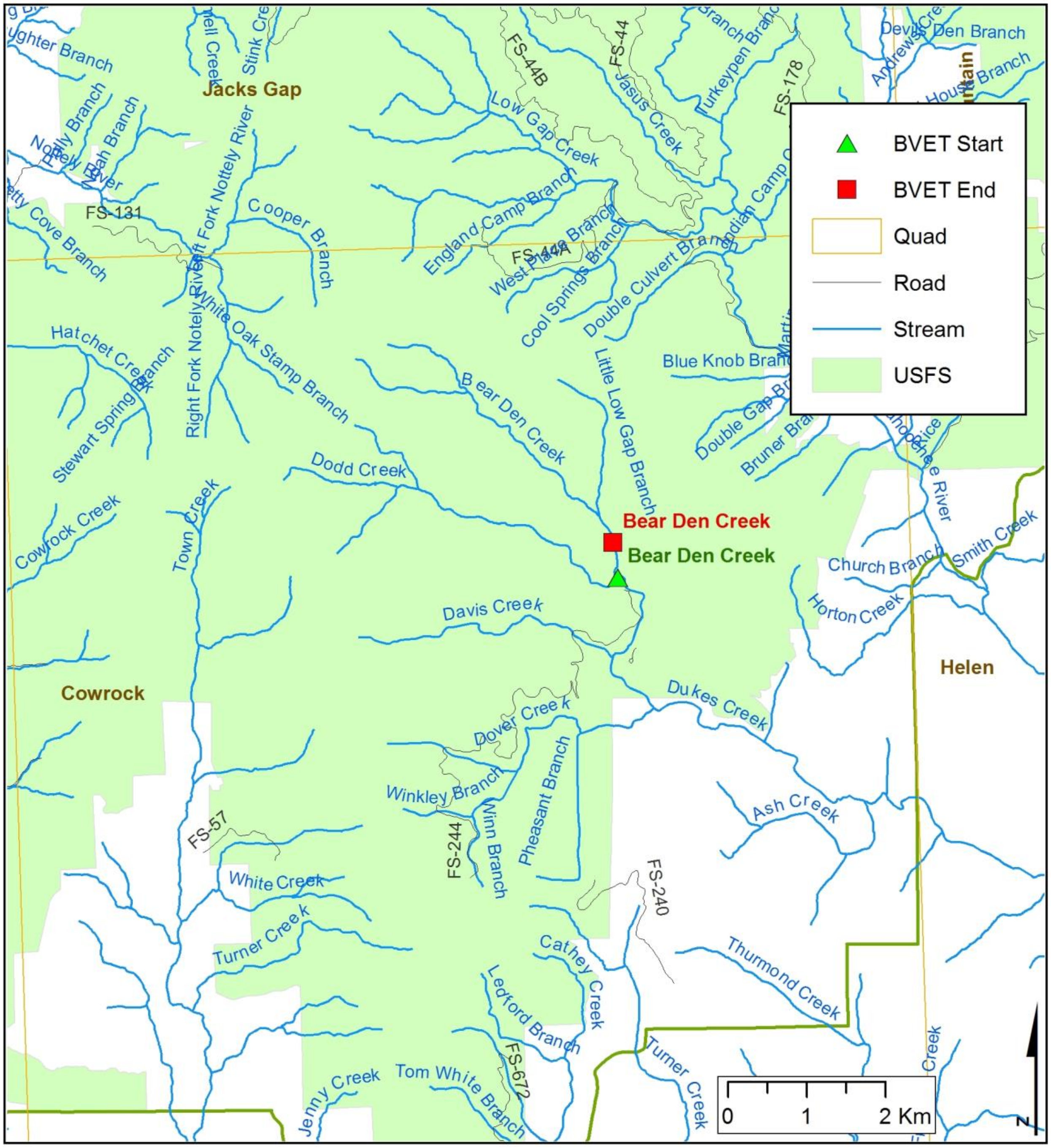


Figure 4. BVET inventory start and end location on Bear Den Creek on the Chattahoochee National Forest, Georgia.

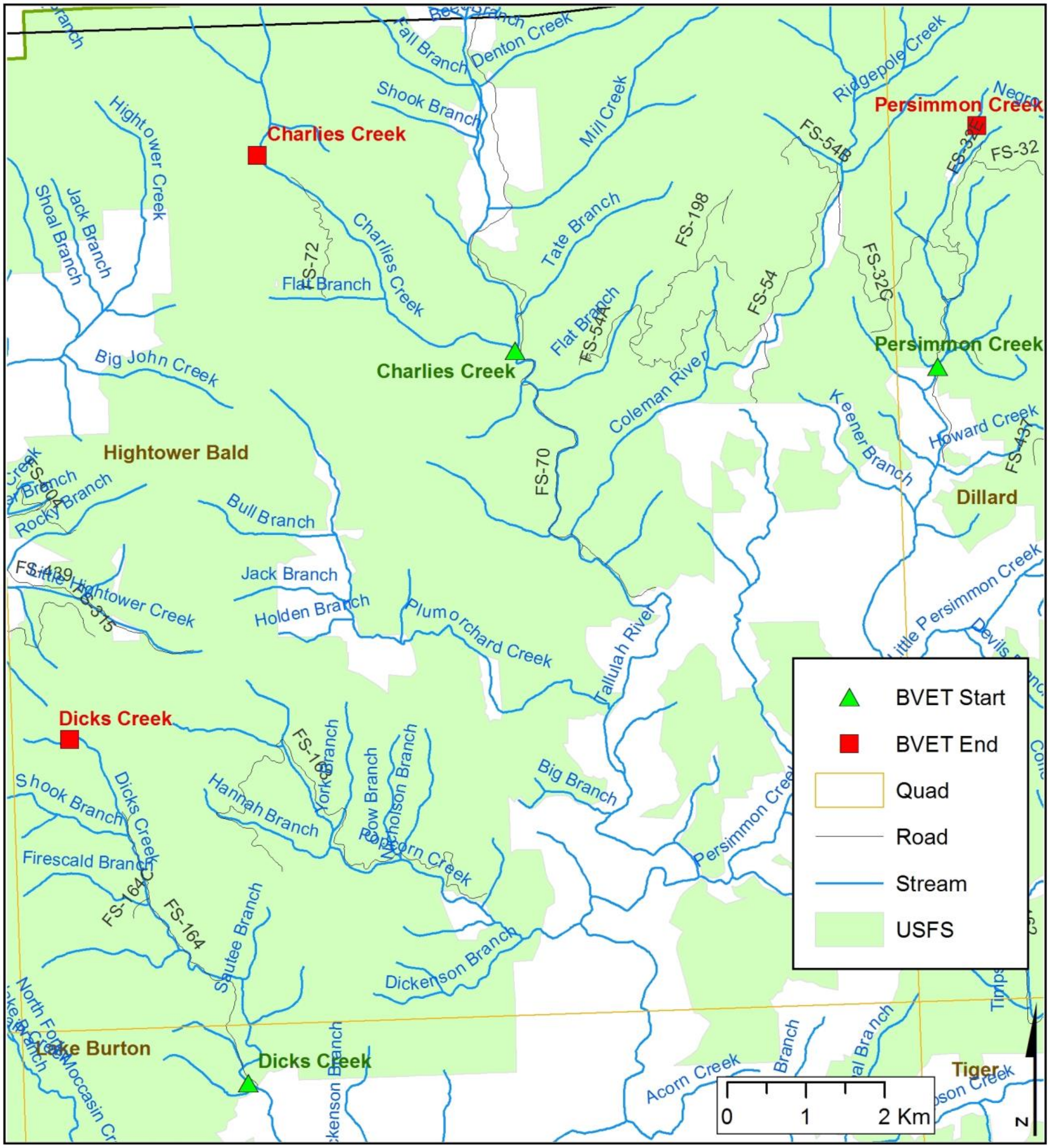


Figure 5. BVET inventory start and end locations on Dicks Creek, Charlies Creek, and Persimmon Creek on the Chattahoochee National Forest, Georgia.

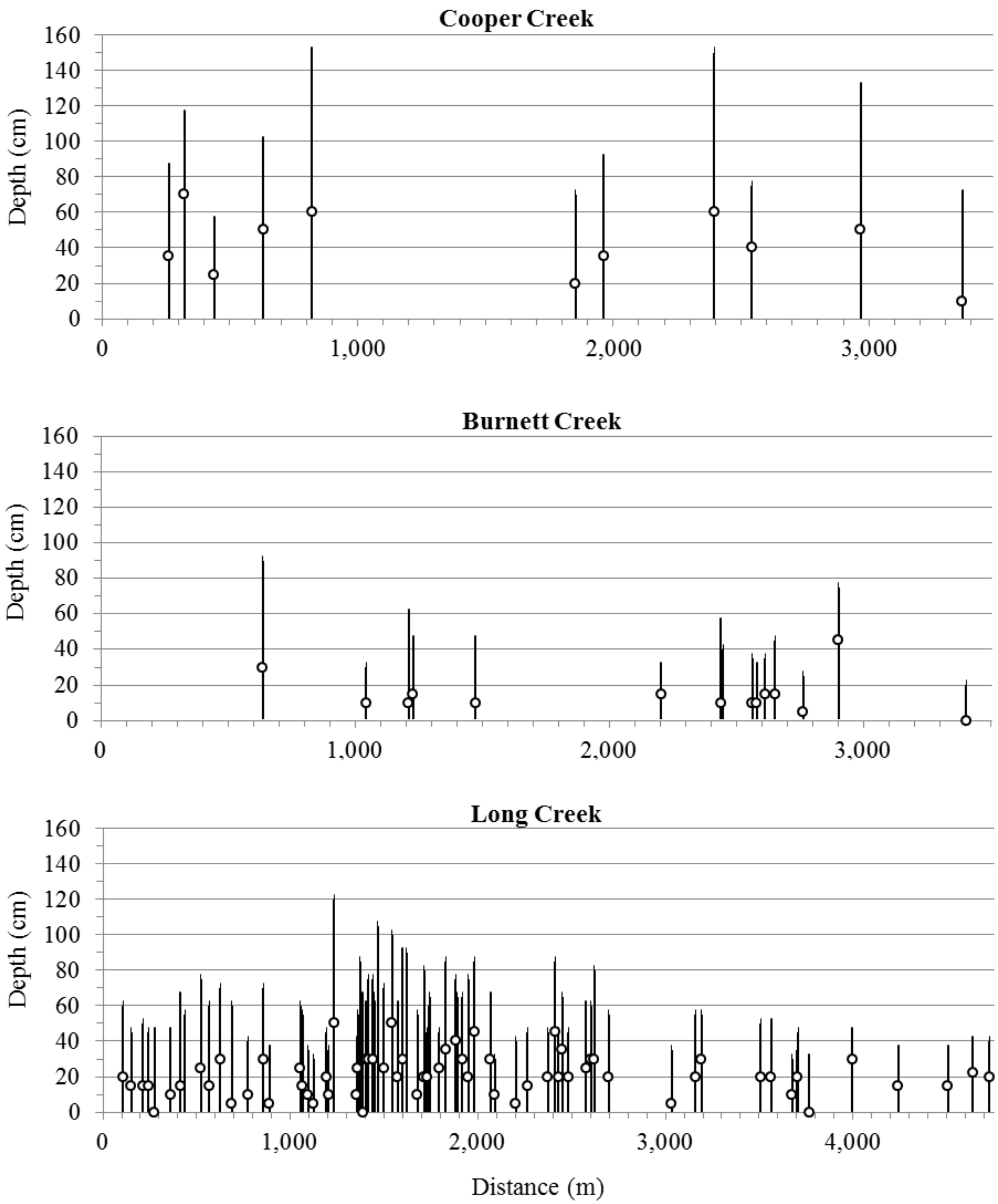


Figure 6. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

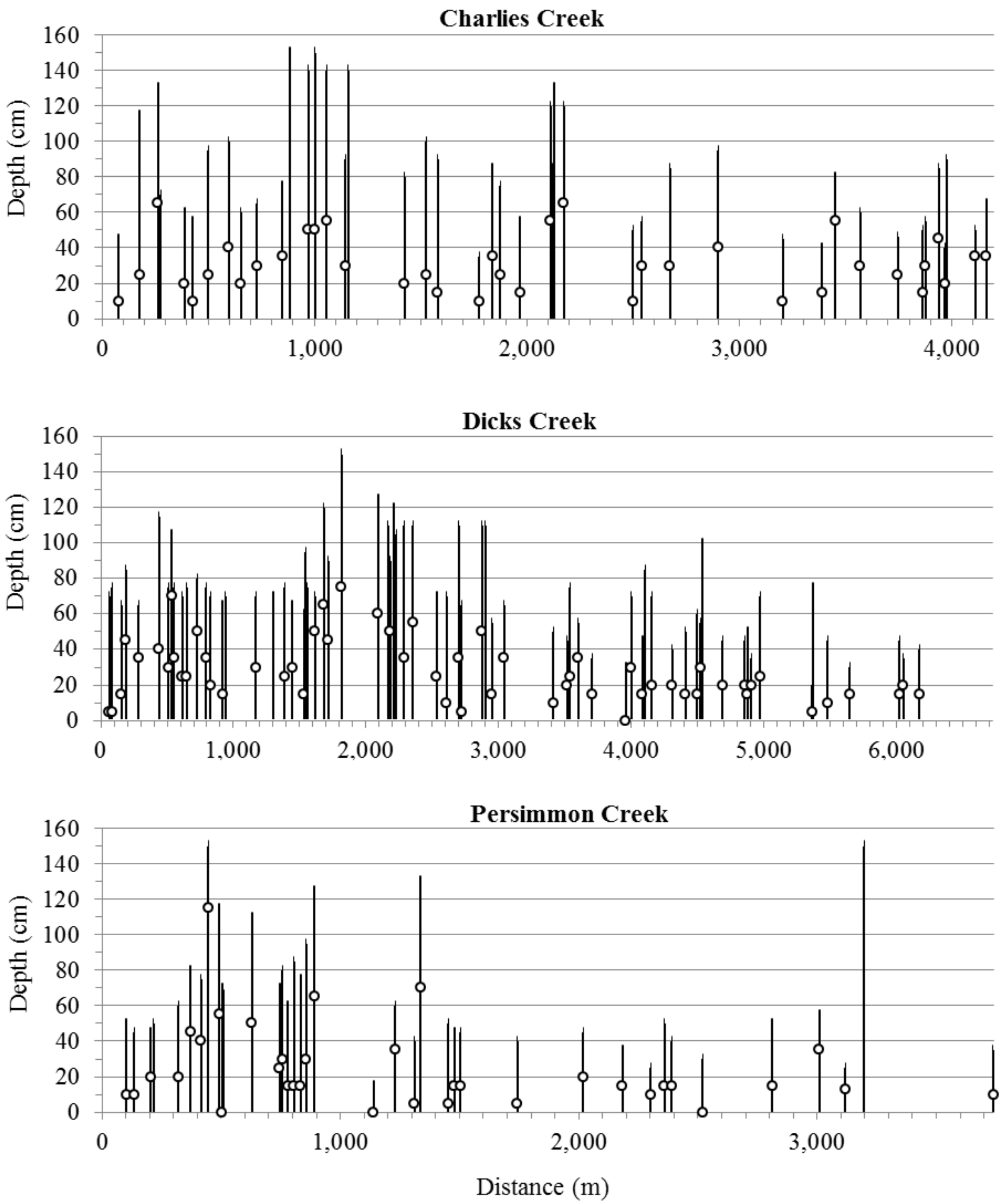


Figure 6 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

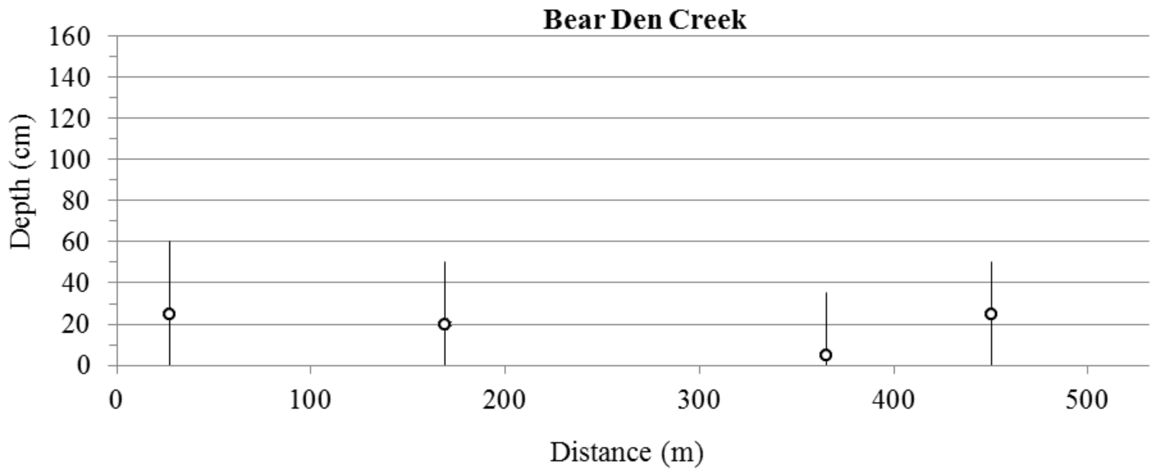


Figure 6 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

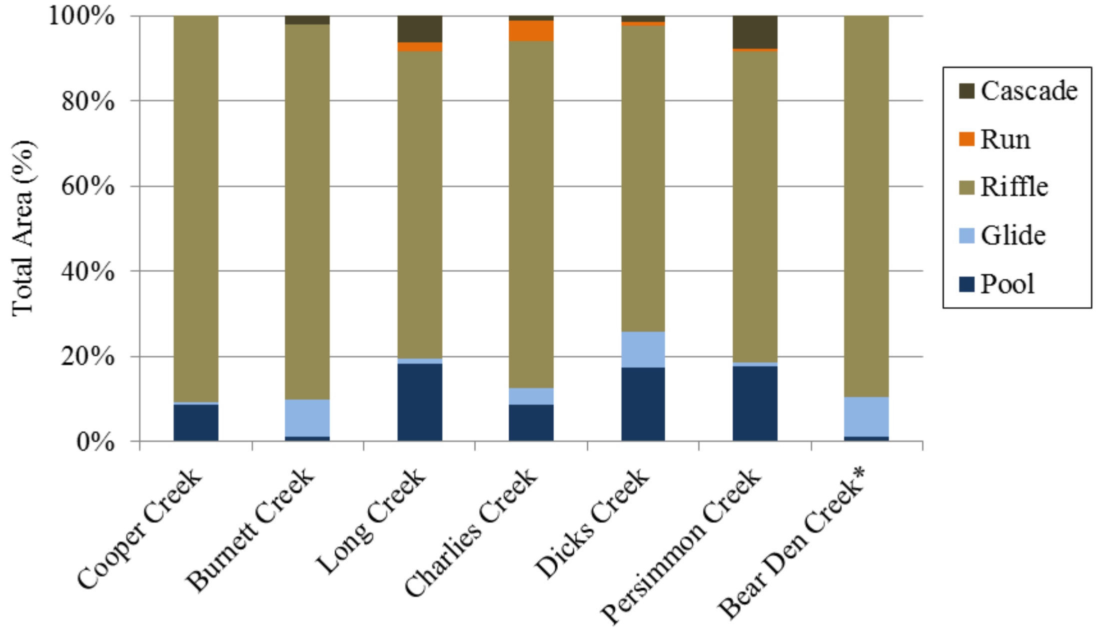


Figure 7. Percent pool, glide, riffle, run, and cascade habitat area. *Uncorrected visually estimated wetted stream widths used to calculate habitat area due to lack of measured paired samples.

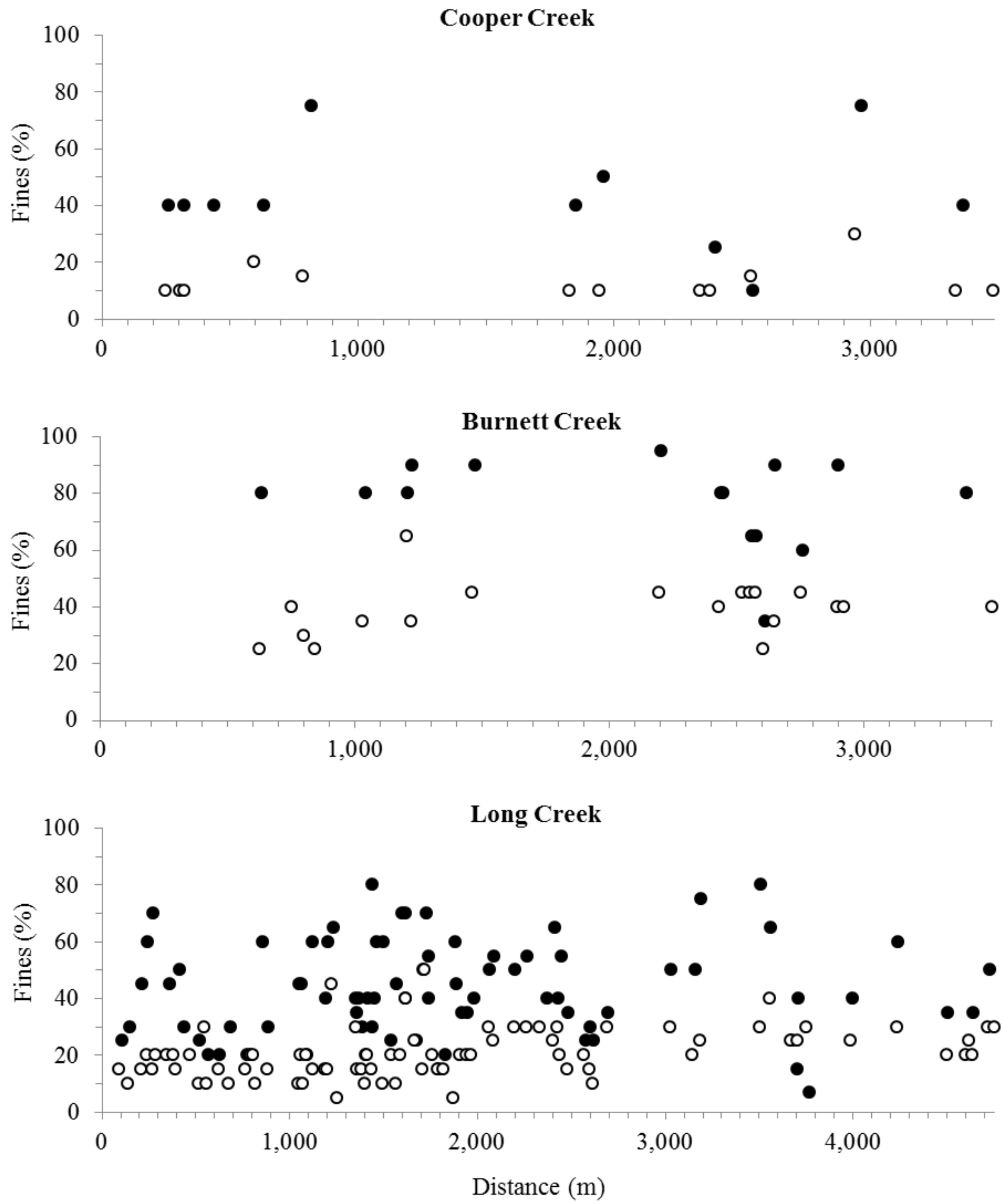


Figure 8. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

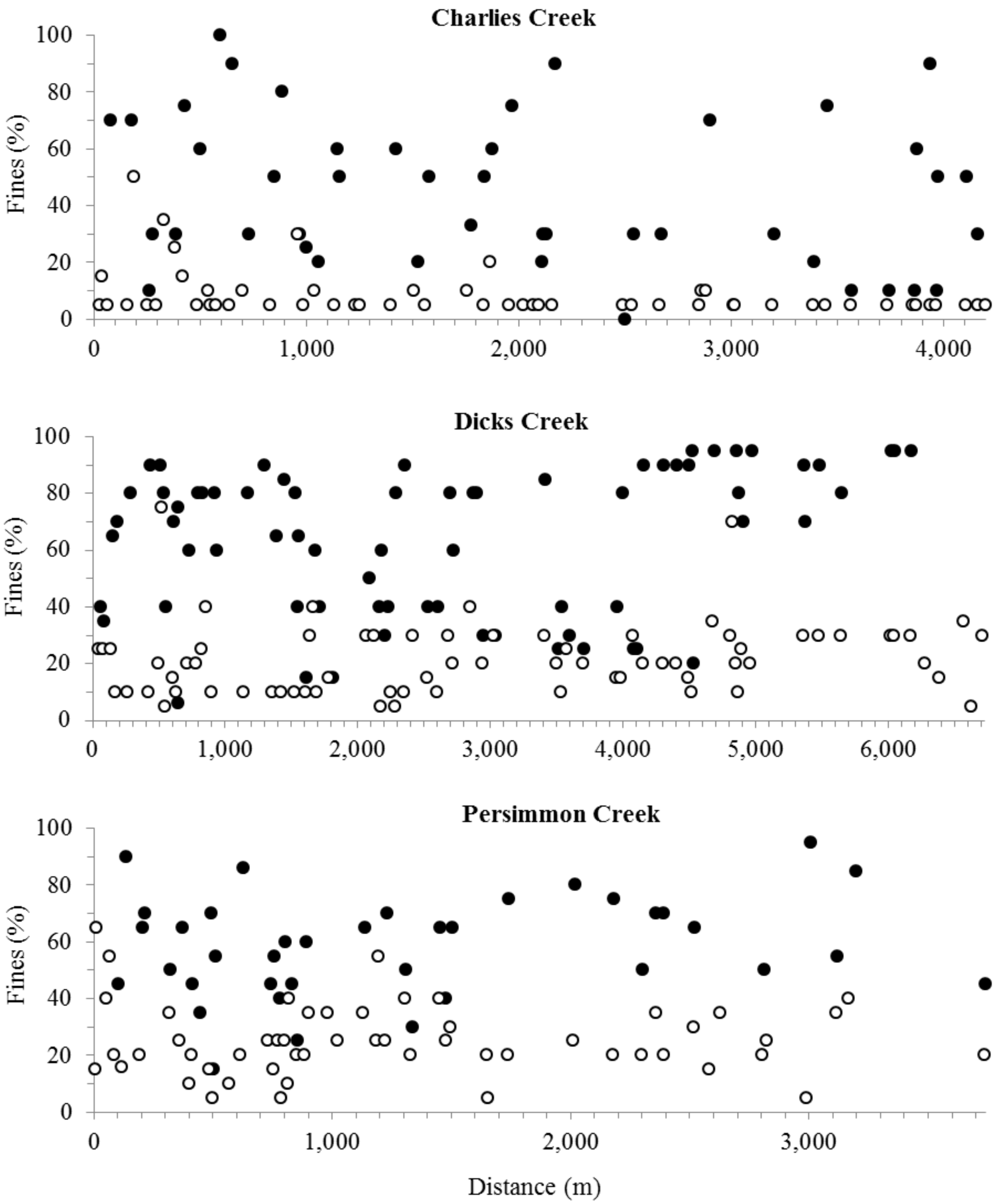


Figure 8 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

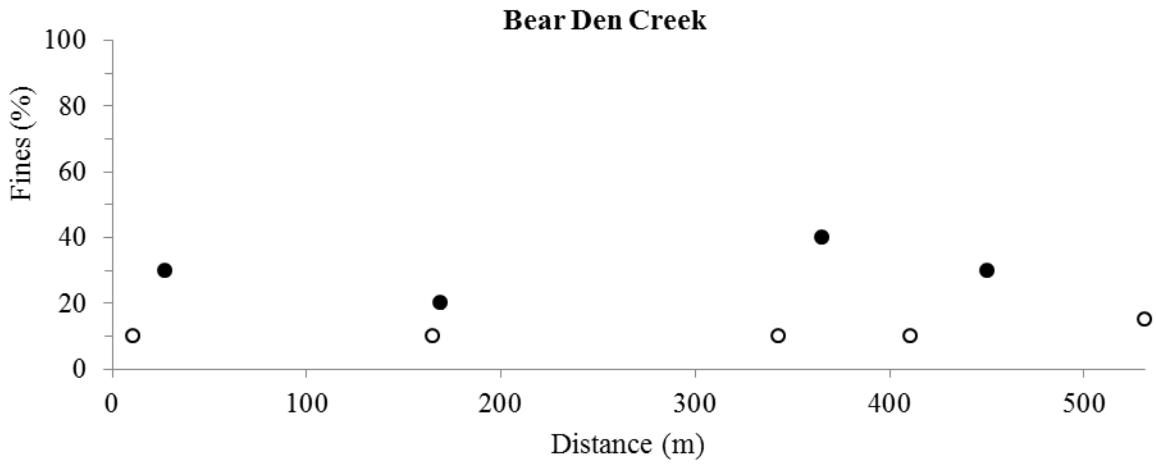


Figure 8 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

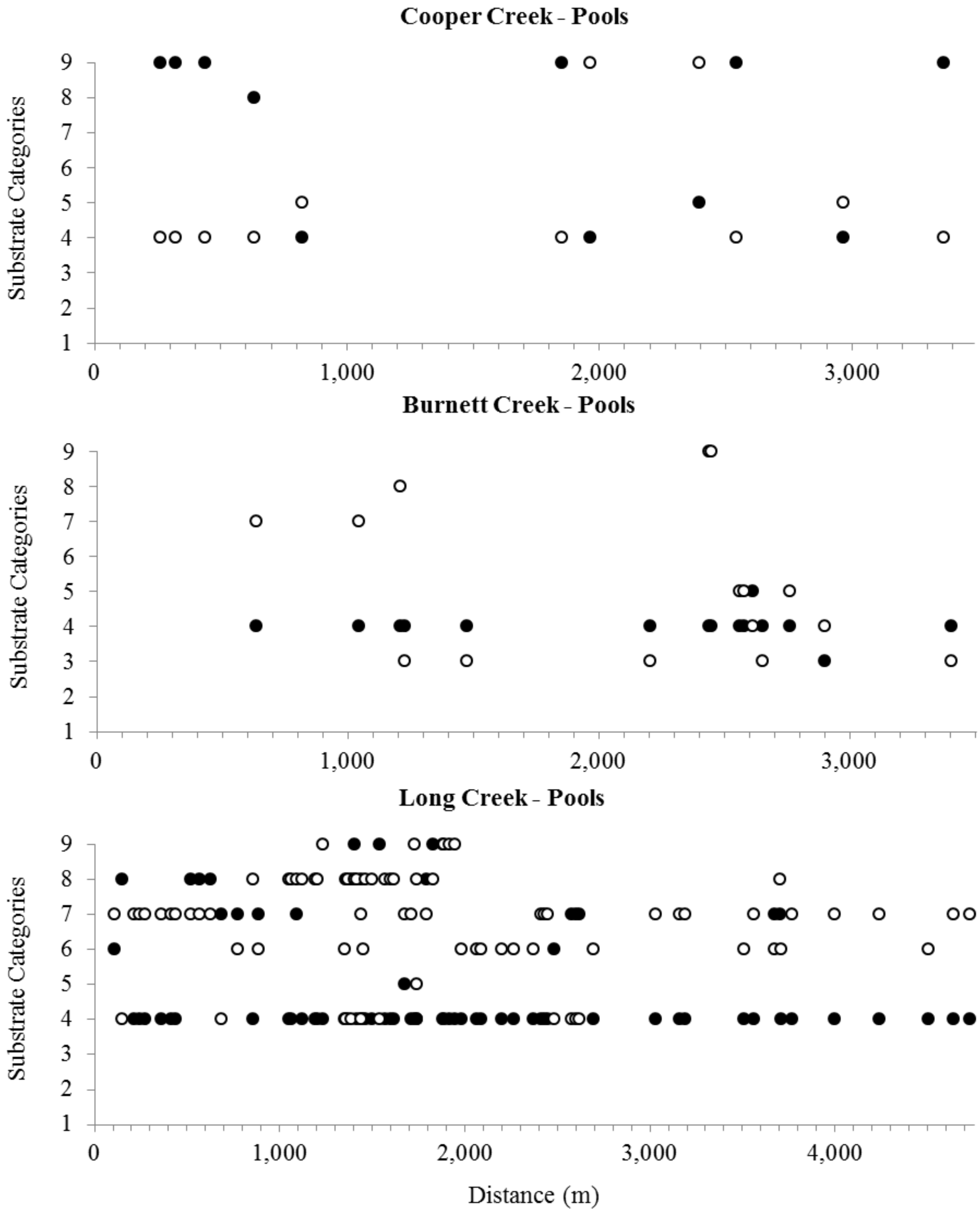
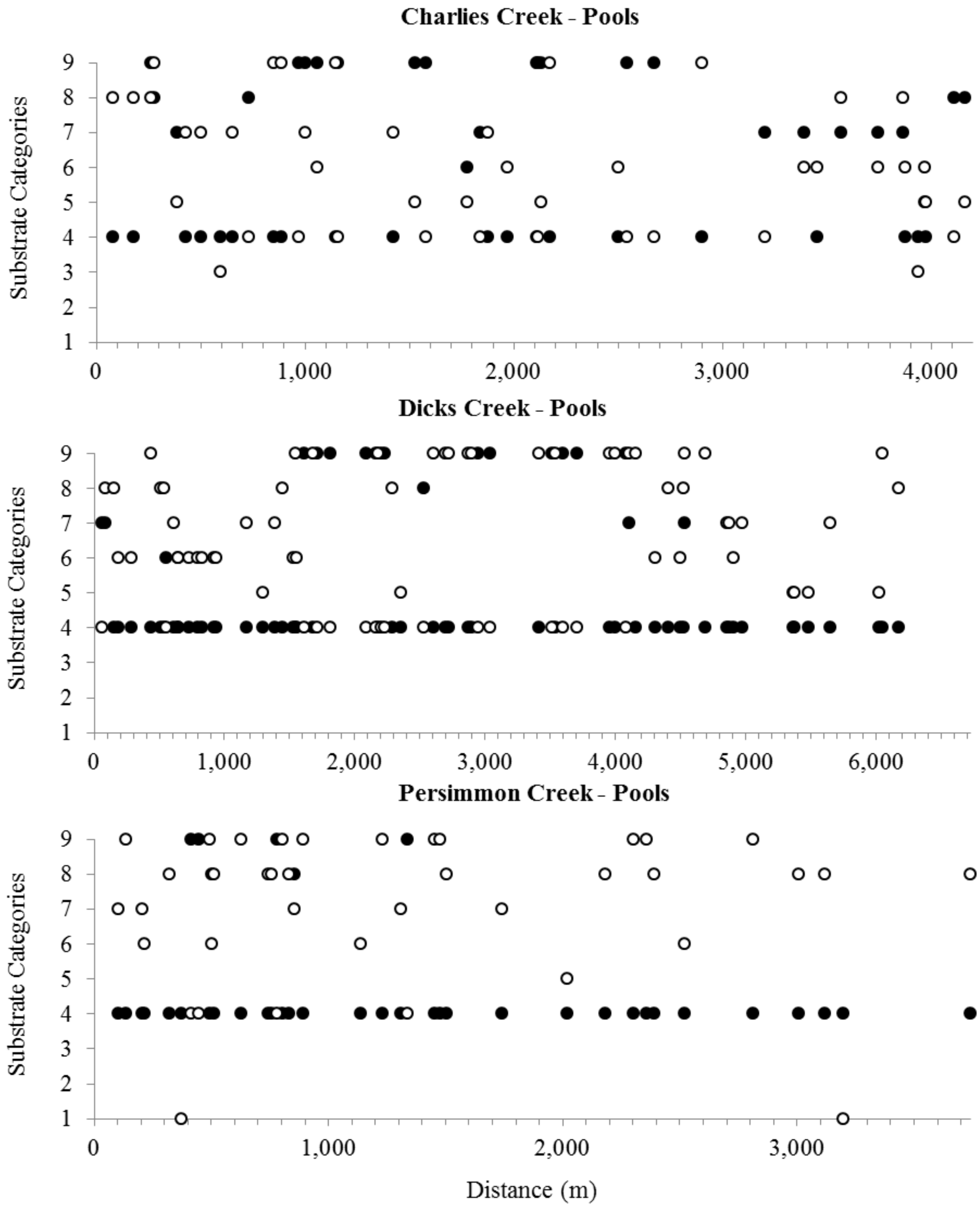


Figure 9. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.



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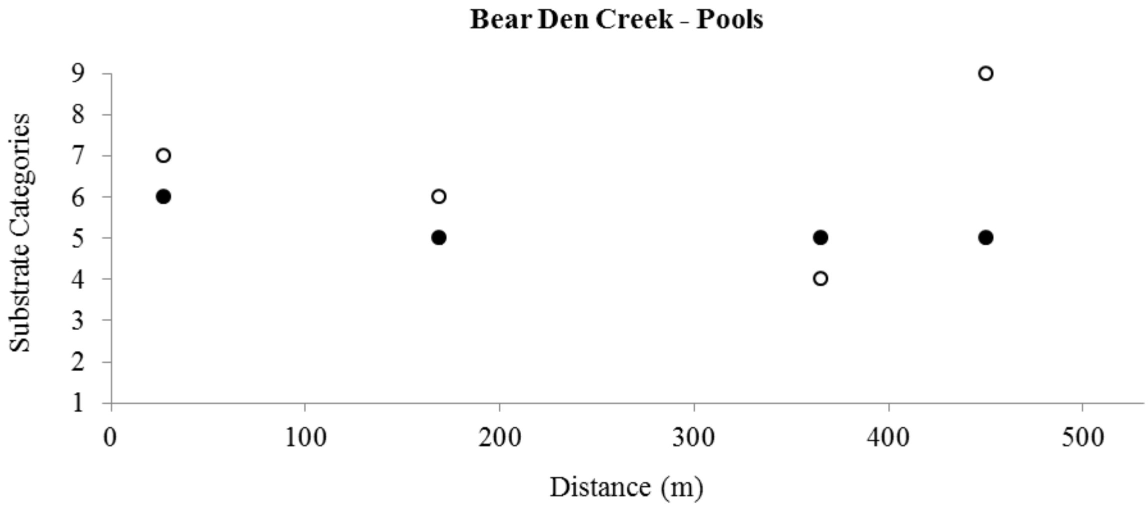

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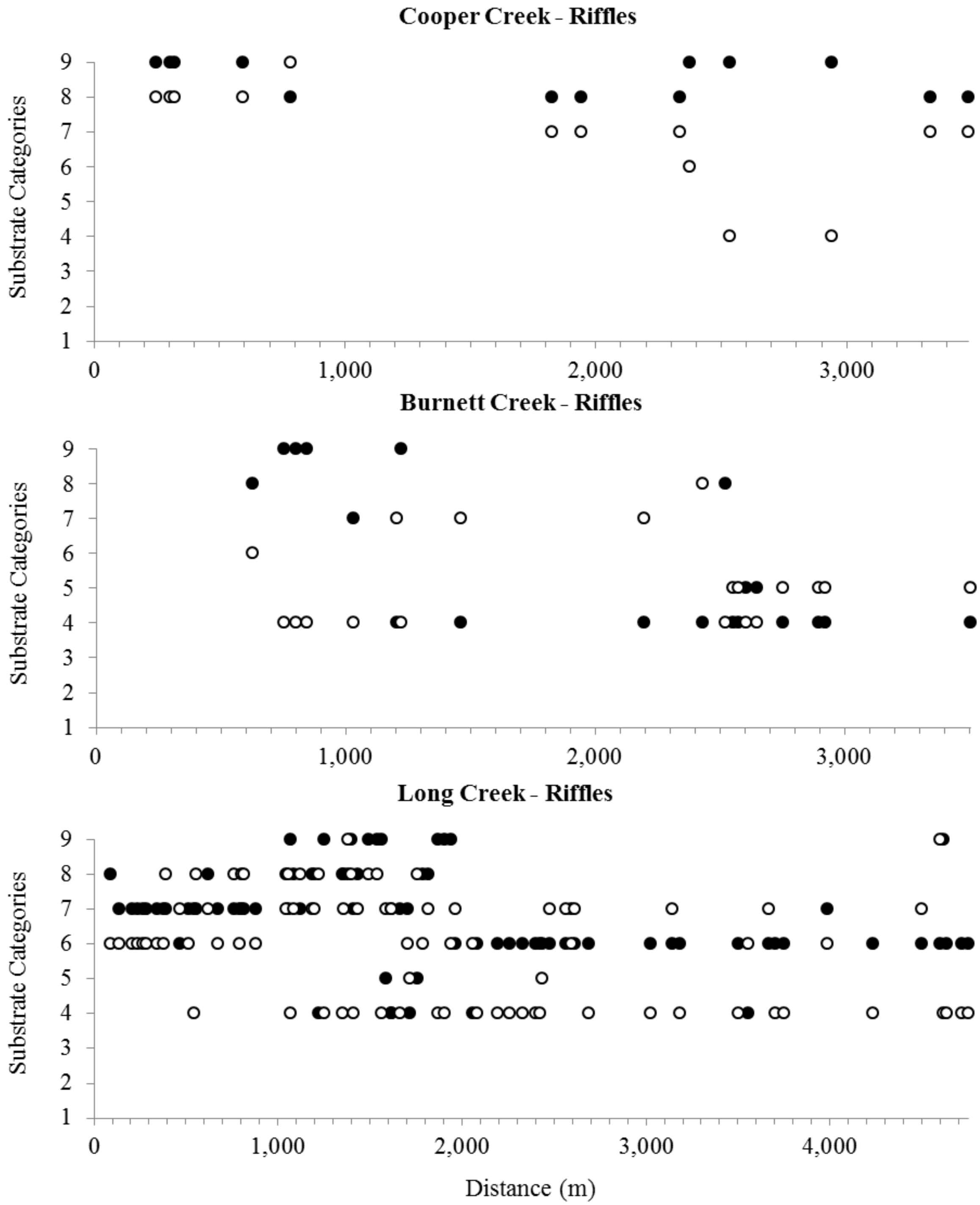


Figure 10. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

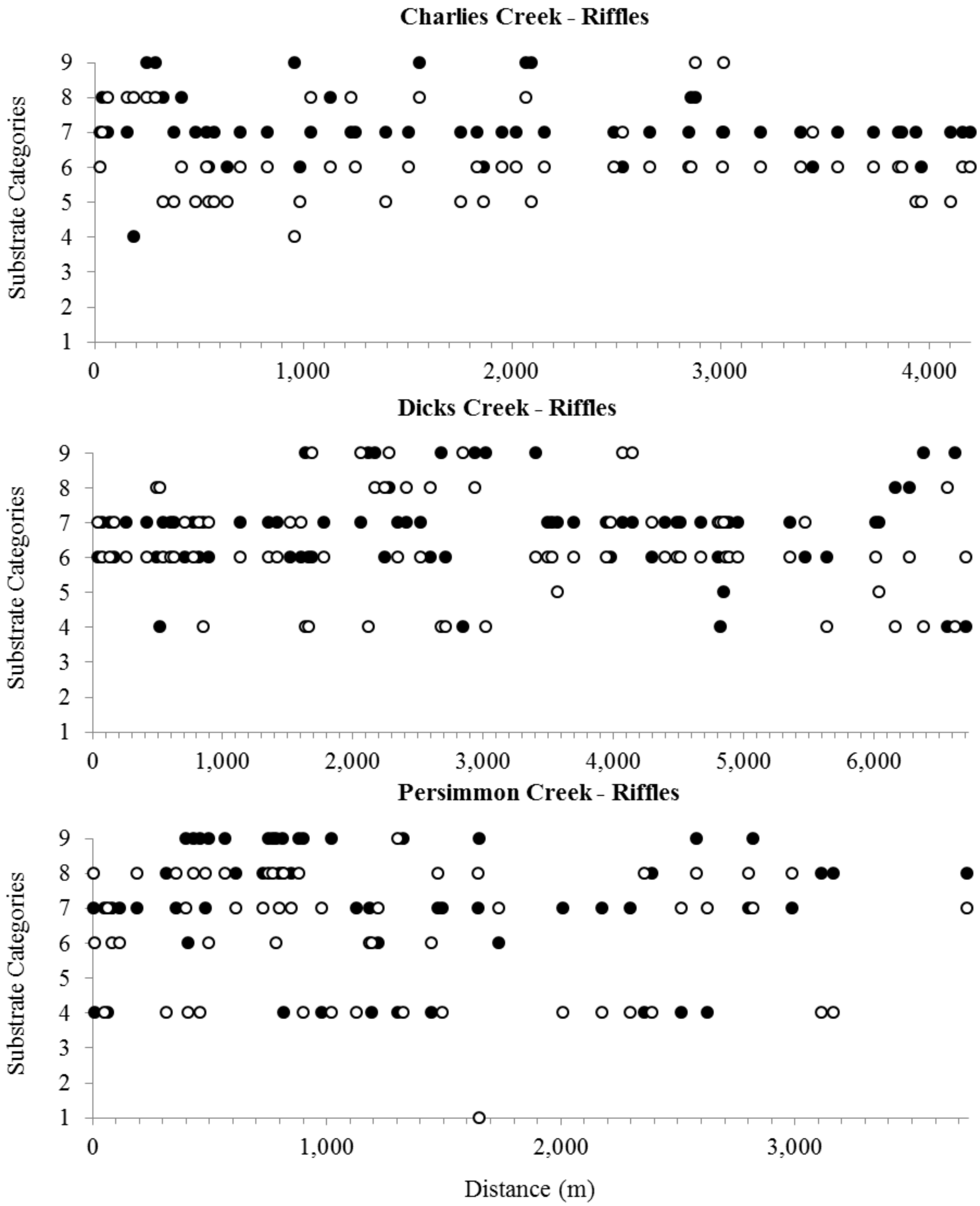


Figure 10 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: <u>1 Organic Matter</u> = dead leaves, detritus, etc.; <u>2 Clay</u> = sticky, holds form; <u>3 Silt</u> = slippery, doesn't hold form; <u>4 Sand</u> = silt-2 mm; <u>5 Small Gravel</u> = 3-16 mm; <u>6 Large Gravel</u> = 17-64 mm; <u>7 Cobble</u> = 65-256 mm; <u>8 Boulder</u> = >256 mm; <u>9 Bedrock</u> = solid rock.

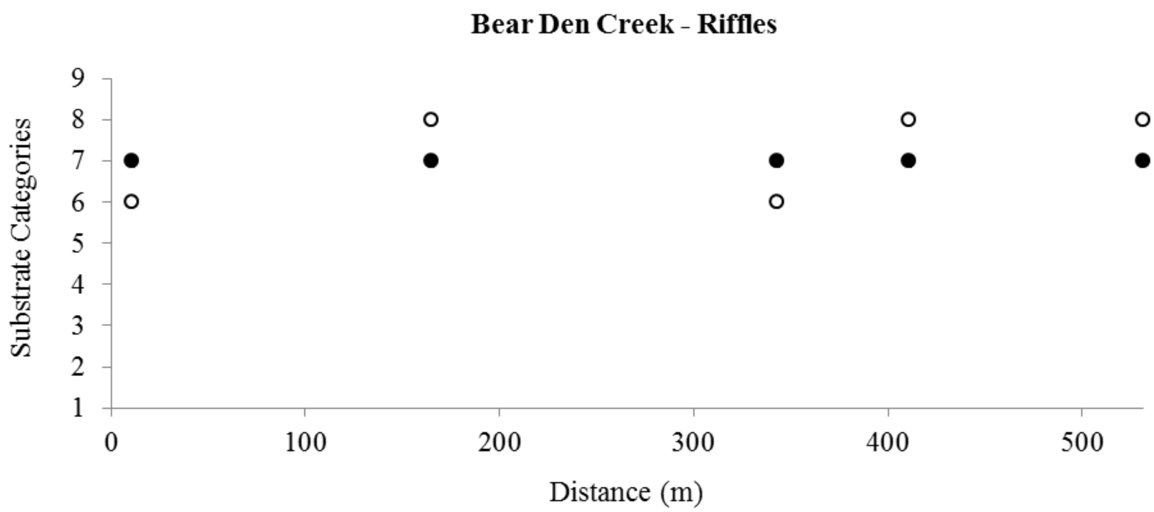


Figure 10 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

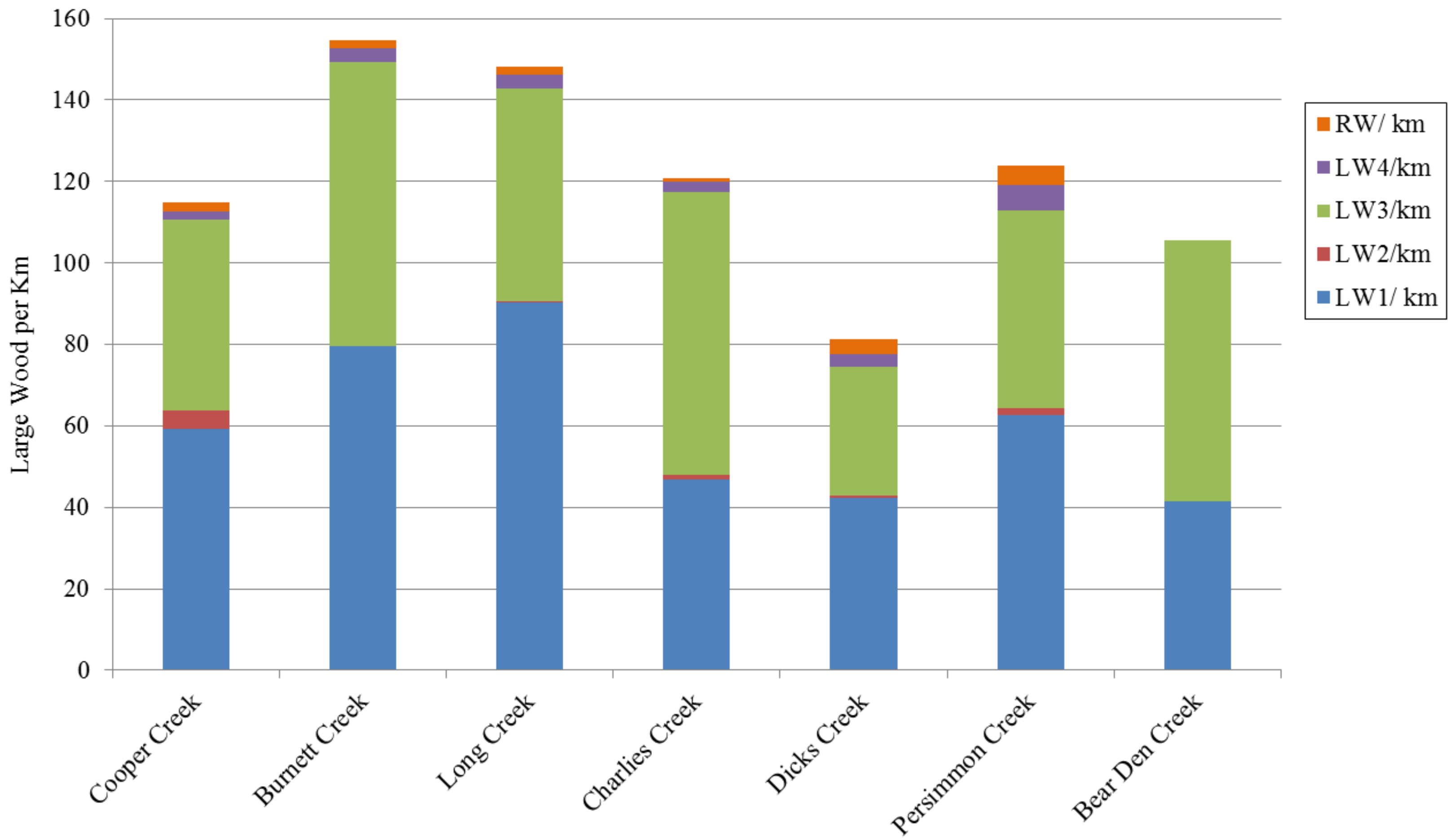


Figure 11. Quantity of large wood (LW; dead and down, any part within bankfull channel) per kilometer. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter; RW = rootwad.

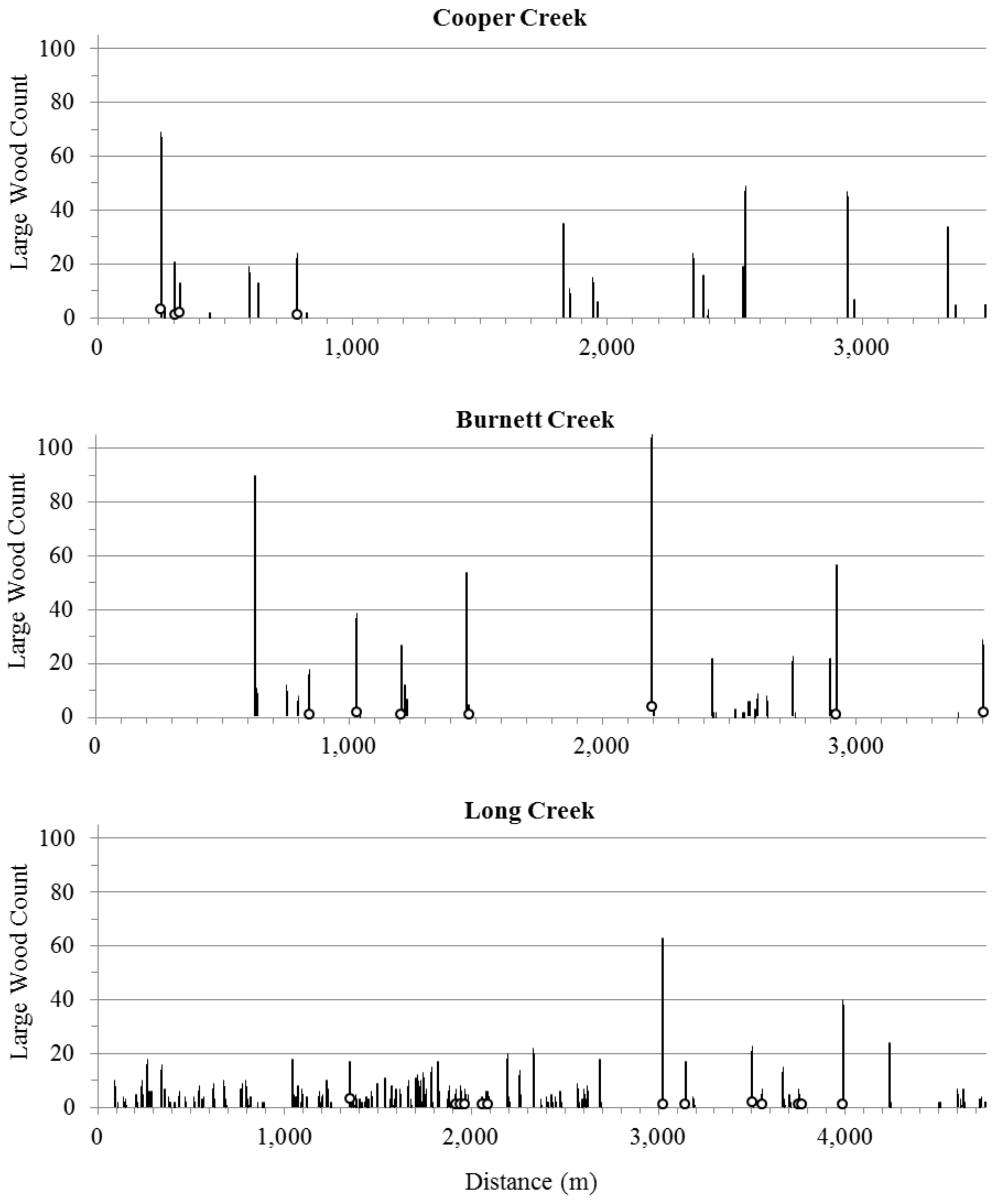


Figure 12. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Cooper Cr. LW n=400 and habitat unit n=24, Burnett Cr. LW n=542 and habitat unit n=34, and Long Cr. LW n=704 and habitat unit n=156.

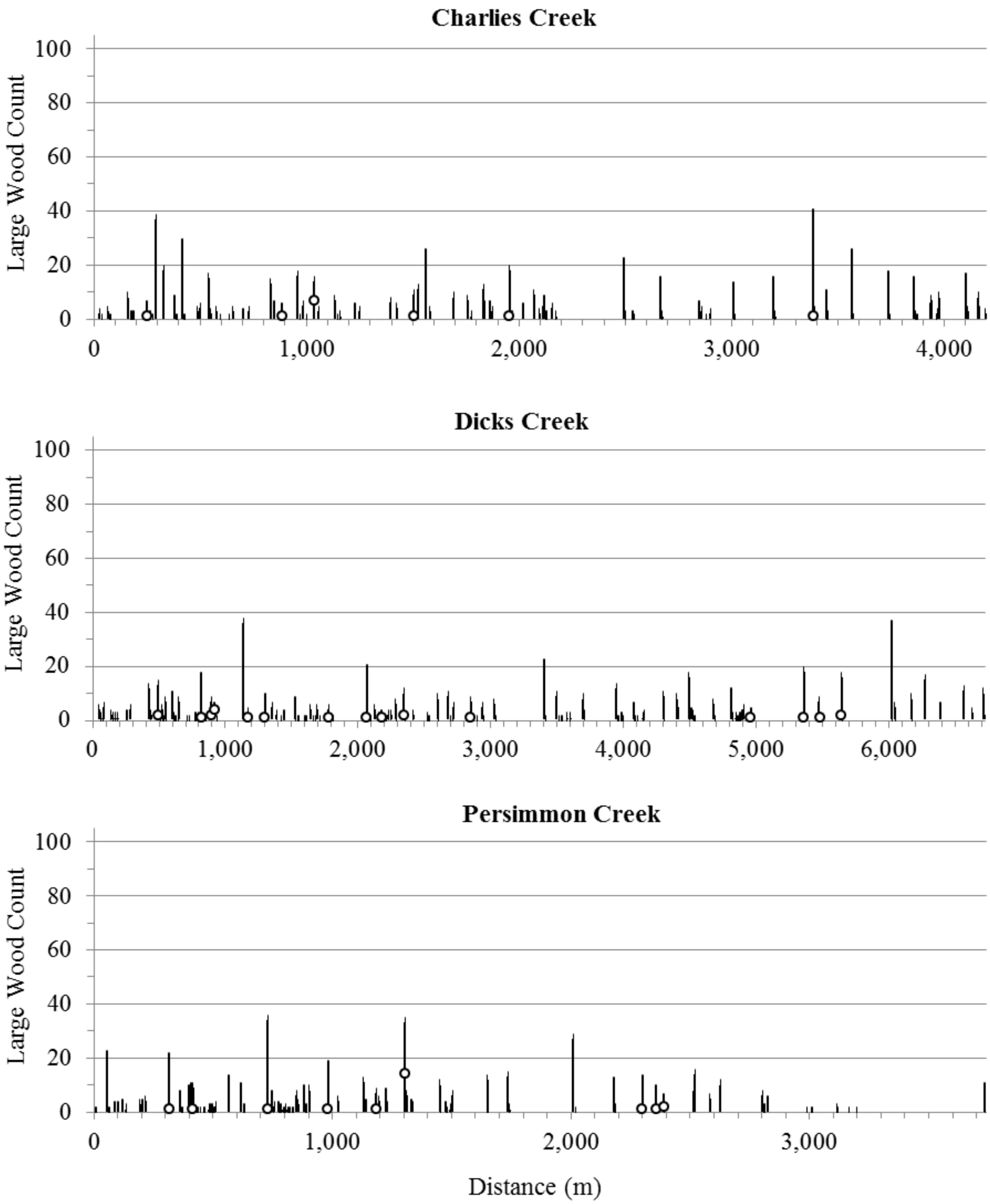


Figure 12 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Charlies Cr. LW n=604 and habitat unit n=99, Dicks Cr. LW n=547 and habitat unit n=142, and Persimmon Cr. LW n=463 and habitat unit n=93.

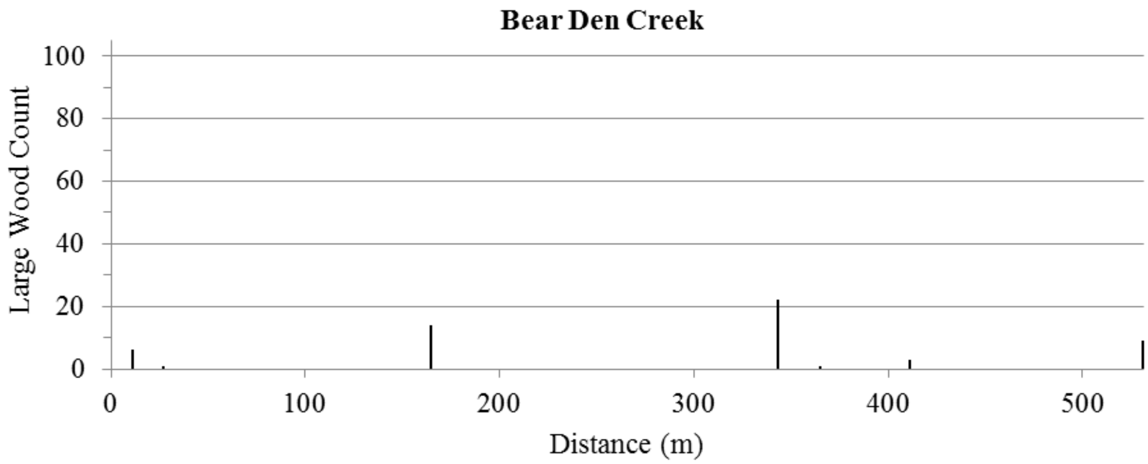


Figure 12 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units in each stream inventoried. Bear Den Cr. LW n=56 and habitat unit n=9.

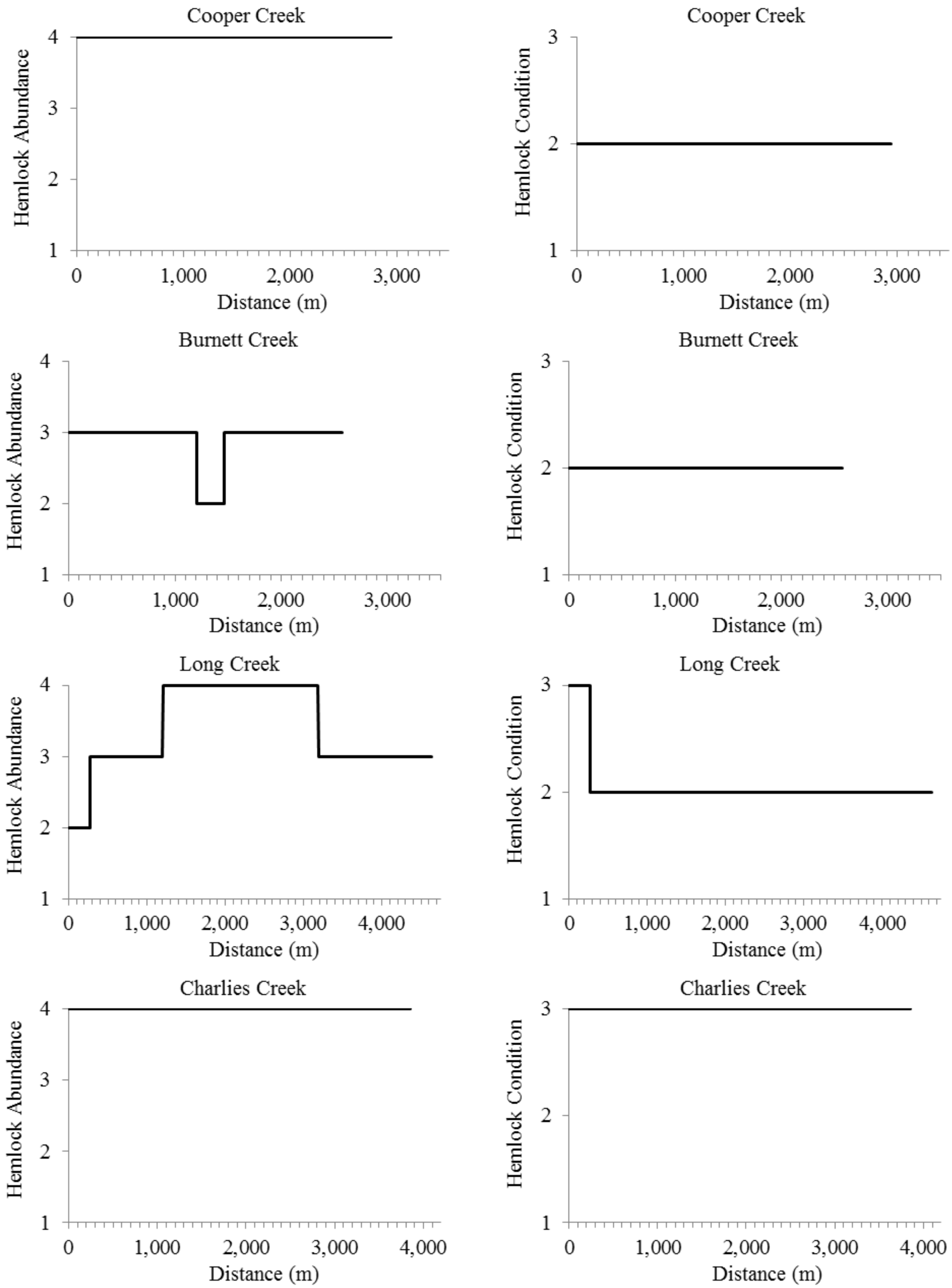


Figure 13. Hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each stream inventory (see appendix A for detailed categories).

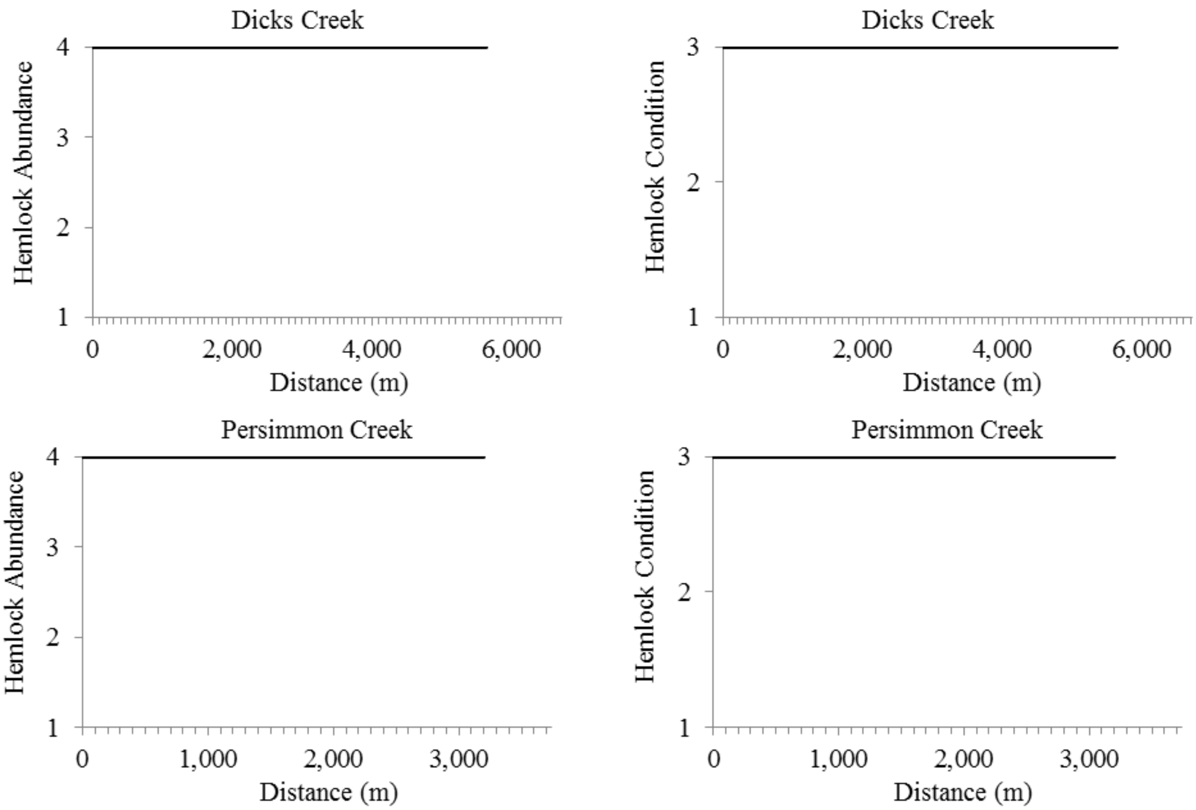


Figure 13 continued. Hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each stream inventory (see appendix A for detailed categories).

Table 1. Summary of streams inventoried on the Chattahoochee National Forest, 2015.

Site #	Stream Name	Topo Quad	Date Start	Date End	BVET habitat (km)	Start Location/Comment
2015-01	Cooper Creek	Mulky Gap	7/11/15	7/12/15	3.5	821 m downstream of Bryant Cr. tributary
2015-02	Burnett Creek	Mulky Gap	7/12/15	7/13/15	3.5	Confluence with Cooper Cr.
2015-03	Long Creek	Noontootla	7/11/15	7/14/15	4.8	Confluence with Chester Cr.
2015-04	Davis Creek	Noontootla				Not inventoried; crew surveyed wrong stream
2015-05	North Fork Moccasin Cr.	Lake Burton, Tray Mtn.				Not inventoried; no access, bad roads
2015-06	Charlies Creek	Hightower Bald	7/8/15	7/10/15	5.0	~10 m upstream of confluence with Tullulah R.
2015-07	Dicks Creek	Lake Burton, Hightower Bald	7/11/15	7/14/15	6.7	Ford on USFS Rd. 164
2015-08	Persimmon Creek	Dillard	7/7/15	7/9/15	3.7	Stream crosssing on USFS Rd. 32
2015-09	Left Fork Soquee River	Tray Mountain				Not inventoried; flooded all 3 days visited
2015-10	Bear Den Creek	Cowrock	7/14/15	7/14/15	0.5	Confluence with Dodd Cr.; ended early, flooding
2015-11	Keener Creek	Dillard				Not inventoried; no access via private roads
2015-12	Ramey Creek	Rabun Bald				Not inventoried; no access, bad roads
				Total	27.7	

Table 2. GPS coordinates recorded at the downstream (start) and upstream (end) extent of stream habitat inventories.

		GPS (NAD83)	
Site #	Stream Name	Downstream Inventory Start	Upstream Inventory End
2015-01	Cooper Creek	N34.75768 W84.04645	N34.75570 W84.01977
2015-02	Burnett Creek	N34.75566 W84.01986	N34.77702 W84.00256
2015-03	Long Creek	N34.66398 W84.18467	N34.66788 W84.14663
2015-04	Davis Creek*	N34.65606 W84.17937	N34.65520 W84.18372
2015-06	Charlies Creek	N34.95127 W83.55306	N34.97467 W83.58805
2015-07	Dicks Creek	N34.86835 W83.59375	N34.90841 W83.61694
2015-08	Persimmon Creek	N34.94777 W83.49428	N34.97518 W83.48760
2015-10	Bear Den Creek	N34.71142 W83.79070	N34.71552 W83.79123

*Coordinates are in the wrong location and not on Davis Creek; crew went up nearby unnamed tributary to Chester Creek.

Table 3. Summary of BVET stream habitat attribute averages collected.

Site #	Stream Name	Mean Avg. Depth (cm)		Mean Max. Depth (cm)		Mean Residual Pool Depth (cm)**	Avg. Wetted Width (m)		Avg. % Fines	
		Pools	Riffles	Pools	Riffles		Pools	Riffles	Pools	Riffles
2015-01	Cooper Creek	59	37	99	63	41	11.0	14.4	43	13
2015-02	Burnett Creek	25	13	44	42	14	3.0	3.4	77	39
2015-03	Long Creek	37	20	58	41	21	5.4	4.3	43	21
2015-06	Charlies Creek	52	25	83	55	30	4.5	5.3	45	9
2015-07	Dicks Creek	40	19	72	43	27	6.3	4.4	64	22
2015-08	Persimmon Creek	38	18	68	43	25	7.2	3.5	58	25
2015-10	Bear Den Creek	33	16	49	30	19	5.0*	5.4*	30	11

*Uncorrected visually estimated wetted stream widths used to calculate average wetted width due to lack of measured paired samples.
**Residual pool depth = average pool depth – riffle crest depth

Table 4. Stream area and unit count of pool, glide, riffle, run, and cascade habitat as observed during BVET habitat inventories.

Site #	Stream Name	Habitat Area (m^2)						Percent Area					Unit Count				
		Pool	Glide	Riffle	Run	Cas-cade	Total	Pool	Glide	Riffle	Run	Cas-cade	Pool	Glide	Riffle	Run	Cas-cade
2015-01	Cooper Creek	3,936	182	41,099	0	0	45,217	9%	0%	91%	0%	0%	10	1	13	0	0
2015-02	Burnett Creek	140	1,065	10,672	0	263	12,140	1%	9%	88%	0%	2%	6	9	18	0	1
2015-03	Long Creek	3,202	220	12,610	387	1,093	17,513	18%	1%	72%	2%	6%	71	5	67	5	8
2015-06	Charlies Creek	1,860	854	17,766	1,060	230	21,770	9%	4%	82%	5%	1%	31	13	42	10	3
2015-07	Dicks Creek	5,058	2,456	21,167	256	430	29,366	17%	8%	72%	1%	1%	45	26	62	4	5
2015-08	Persimmon Creek	2,265	129	9,461	77	1,008	12,940	18%	1%	73%	1%	8%	36	2	38	3	14
2015-10	Bear Den Creek*	32	308	2,888	0	0	3,228	1%	10%	89%	0%	0%	1	3	5	0	0

*Uncorrected visually estimated wetted stream widths used to calculate average wetted width due to lack of measured paired samples.

Table 5. Percent occurrence of dominant and subdominant substrate size categories in pools (includes glides) and riffles (includes cascades and runs) in each stream inventoried. See appendix A for substrate size categories.

		Pool Dominant Substrate									Riffle Dominant Substrate								
Site #	Stream Name	Organic Matter	Clay	Silt	Sand	Small Gravel	Large Gravel	Cobble	Boulder	Bedrock	Organic Matter	Clay	Silt	Sand	Small Gravel	Large Gravel	Cobble	Boulder	Bedrock
2015-01	Cooper Creek	0	0	0	27	9	0	0	9	55	0	0	0	0	0	0	0	46	54
2015-02	Burnett Creek	0	0	7	87	7	0	0	0	0	0	0	0	53	11	0	5	11	21
2015-03	Long Creek	0	0	0	70	1	3	12	11	4	0	0	0	8	3	33	30	15	13
2015-06	Charlies Creek	0	0	0	43	2	2	16	9	27	0	0	0	2	0	13	63	11	11
2015-07	Dicks Creek	0	0	0	73	0	1	6	1	19	0	0	0	7	1	26	49	4	13
2015-08	Persimmon Creek	0	0	0	84	0	0	0	5	11	0	0	0	18	0	5	31	16	29
2015-10	Bear Den Creek	0	0	0	0	75	25	0	0	0	0	0	0	0	0	0	100	0	0
	Average	0	0	1	55	13	4	5	5	16	0	0	0	12	2	11	40	15	20
		Pool Subdominant Substrate									Riffle Subdominant Substrate								
2015-01	Cooper Creek	0	0	0	64	18	0	0	0	18	0	0	0	15	0	8	38	31	8
2015-02	Burnett Creek	0	0	33	13	20	0	13	7	13	0	0	0	42	32	5	16	5	0
2015-03	Long Creek	0	0	0	13	1	20	34	24	8	0	0	0	33	3	24	24	15	3
2015-06	Charlies Creek	0	0	5	25	14	18	14	11	14	0	0	0	2	26	46	6	17	4
2015-07	Dicks Creek	0	0	0	23	9	20	10	13	26	0	0	0	16	3	43	19	11	9
2015-08	Persimmon Creek	5	0	0	11	3	11	13	29	29	2	0	0	27	0	15	24	31	2
2015-10	Bear Den Creek	0	0	0	25	0	25	25	0	25	0	0	0	0	0	40	0	60	0
	Average	1	0	5	25	9	13	16	12	19	0	0	0	19	9	26	18	24	3

Table 6. Large wood (LW) per kilometer observed during BVET habitat inventories. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter; RW = rootwad.

Site #	Stream Name	Large Wood per Km						Large Wood Count in Sample Reach						Inventory
		LW1/ km	LW2/ km	LW3/ km	LW4/ km	RW/ km	Total LW/km	LW1 n	LW2 n	LW3 n	LW4 n	RW n	Total LW n	Distance (km)
2015-01	Cooper Creek	59	5	47	2	2	115	206	16	163	7	8	400	3.5
2015-02	Burnett Creek	80	0	70	3	2	155	279	0	244	12	7	542	3.5
2015-03	Long Creek	90	0	52	3	2	148	429	1	249	16	9	704	4.8
2015-06	Charlies Creek	47	1	70	2	1	121	234	5	348	12	5	604	5.0
2015-07	Dicks Creek	42	0	32	3	4	81	285	3	212	22	25	547	6.7
2015-08	Persimmon Creek	63	2	48	6	5	124	234	7	181	23	18	463	3.7
2015-10	Bear Den Creek	41	0	64	0	0	105	22	0	34	0	0	56	0.5

Appendix A: Field Methods for Stream Habitat Inventory

Guide to Stream Habitat Characterization using the BVET Methodology in the Chattahoochee National Forest, GA

Prepared by:

CENTER FOR AQUATIC TECHNOLOGY TRANSFER

CATT

Prepared by: Colin Krause and Craig N. Roghair

2015

Table of Contents

Introduction

The Basinwide Visual Estimation Technique (BVET) is a versatile tool used to assess streamwide habitat conditions in wadeable size streams and rivers. A crew of two individuals performs the inventory using two-stage visual estimation techniques described in Hankin and Reeves (1988) and Dolloff et al. (1993). In its most basic form the BVET combines visual estimates with actual measurements to provide a calibrated estimate of stream area with confidence intervals, however the crew may inventory any number of other habitat attributes as they walk the length of the stream. Experienced crews can inventory an average of 2-3 km per day, but this will vary depending on stream size and the number of stream attributes inventoried.

Before a crew begins a BVET inventory they must receive adequate training, both in the classroom and in the field. Estimating and measuring a large number of habitat attributes can confuse and overwhelm an inexperienced crew. Individuals must have an understanding of the basic concepts behind the BVET and be familiar with habitat attributes before they can effectively and efficiently perform an inventory.

This document was developed to serve as a guide for classroom and field instructions specific to the Chattahoochee National Forest BVET habitat inventory and to provide a post-training reference for field crews. It includes an overview of the BVET inventory, defines habitat attributes, instructs how and when to measure attributes, and provides reference sheets for use in the field. Each trainee should receive a copy of this manual and is encouraged to take notes in the spaces provided.

References cited in this manual:

Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Southeastern Forest Experimental Station.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colorado.

Rosgen, D.L., and L. Silvey. 1998 Field Guide for Stream Classification, Wildland Hydrology Books, Pagosa Springs, Colorado.

Changes to BVET inventory in 2015

Attribute	Action	Reason
Hemlock LW	added	Quantify hemlock LW in bankfull channel
Hemlock Condition	changed	Combined categories 0 & 1; combined categories 4&5 from 2014 methods; now using 3 categories instead of 5
Hemlock Abundance	changed	Using same categories, but shifting category labels from 0-3 to 1-4 for consistency with BVET methods used in other National Forests

Other minor changes, mostly modifications in terminology and definitions to provide increased clarity, are found throughout the manual.

Outline of BVET Habitat Inventory

The inventory is comprised of the following steps:

1) Enter 'header' information in the data sheet
    - 'Header' information includes date, stream, start location, crew, etc. and is **vitally** important to record for future reference

2) Select an appropriate measurement interval and a random number
    - In streams < 1.0 km measure every 5th unit (random number 1-5), in streams > 1.0 km measure every 10th unit (random number 1-10)
    - The random number designates the first habitat unit (i.e. the paired sample unit) in which the crew will perform measurements

3) Enter downstream of the starting point, then move upstream and begin the inventory
    - Tie off the hipchain, proceed upstream to the starting point, reset the hipchain to zero, and proceed upstream estimating parameters and recording data in every habitat unit

4) At the paired sample unit perform visual estimates, then perform measurements
    - If the random number '3' were chosen, the crew would stop after making estimates in the 3rd pool (and 3rd riffle) and perform the necessary measurements

5) Progress upstream estimating attributes for every unit until the next paired sample unit is reached, then repeat step 4
    - In the above example, if the interval were 10 units, the crew would stop at the 13th, 23rd, 33rd, etc. pool (and 13th, 23rd, 33rd, etc. riffle) and repeat measurements done in pool 3 and riffle 3.
    - The crew should also take care to record roads, trails, tributaries, dams, waterfalls, road crossing types, riparian features (wildlife openings, trails, campsites, roads, timber harvest, etc.), and other pertinent stream features as they progress upstream. Be sure to record hipchain distances when noting such features.

Repeat steps 4 and 5 until the end of inventory reach.

The following sections describe the BVET habitat inventory in detail:

Section 1: Getting Started – equipment lists, header information, random numbers, starting the inventory

Section 2: Habitat Attributes – definitions, how to estimate or measure, when to record

Section 3: Wrapping Up – what to do when the inventory is completed

Appendix: field guide, random number tables, equipment checklist

Section 1: Getting Started

Equipment List

Hipchain & extra string	Backpack
wading rod	Pencils
50 m tape measure	Flagging
Datalogger	Markers
GPS unit	waterproof backup datasheets
topographic map	BVET manual and field guide
camera	felt bottom wading boots or waders
Clinometer (for cascades)	Water Filter
Thermometer	1st Aid Kit & toilet paper

Other useful equipment: lunch, water, rain gear, radio/cell phone

The crew consists of two individuals, the 'observer' and the 'recorder'. The observer wears the hipchain and carries the wading rod. The recorder wears the data logger and carries other equipment in the backpack. The duties of each individual are listed below.

Duties

Observer	**Recorder**
Designate habitat units	Record data
Measure distance	Determine paired sample location
Estimate width	Classify and count LW
Estimate depths	Hemlock LW, abundance, condition
Classify substrates	Photo-documentation
Estimate percent fines	Document features

Both crew members are needed to measure actual widths, channel widths, riparian areas, gradient, and water temperature at designated units. Although the crew has assigned duties, they should not hesitate to consult with each other if they have questions or feel that a mistake may have been made. Working as a team will provide the best possible results.

Header Information

Header information is **vitally important** for future reference. Take the time to record all categories completely and accurately.

Stream Name	Full name of stream
District	National Forest District name
Quad	USGS 1:24,000 quadrangle name
Date	Record date(s) of inventory
Recorder	Full name of recorder
Observer	Full name of observer
GPS	record at start and end locations, always use NAD27 CONUS, UTM
Location	**Detailed** written description of start point, include landmarks, road #, etc.
Notes	Record signs of activity in area, water conditions, other pertinent information

Random Numbers

Before beginning the inventory, select a number from a random numbers table (see Appendix) to determine the first habitat unit at which to make measurements. For long inventories (> 1.0 km) select a random number between 1 and 10th (i.e. measure every 10 unit), for shorter streams use a number between 1 and 5 (i.e. measure every 5th unit). See the appendix for random numbers tables.

The crew needs to measure units more frequently during shorter inventories to provide enough ‘paired samples’ for data analysis. ‘Paired samples’ are habitat units in which both visual estimates and actual measurements are made. The more paired samples, the tighter the confidence intervals for stream area estimates.

After the crew records a paired sample they continue upstream making visual estimates and stopping to make additional measurements at the pre-determined interval. For example, if the random number was 3 and the crew was measuring every 5th unit, the crew would make measurements on the 3rd pool and 3rd riffle and then every 5th pool and riffle thereafter (8, 13, 18, 23, etc).

Starting the Inventory

After the crew has organized their gear, determined their measurement interval, selected a random number, recorded all the header information, and determined the start location they are ready to begin the habitat inventory. The observer should enter the stream slightly downstream of the starting point, tie off the hipchain, progress upstream to the starting point, reset the hipchain to zero and begin walking upstream through the first habitat unit. As the observer moves upstream they use the wading rod to measure depth at several locations in the habitat unit and make observations of unit type, width, substrates, and percent fines. When they reach the upstream end of the habitat unit they stop, report the distance, then turn to face the unit and report the unit type, estimated width, maximum and average depth, riffle crest depth (where appropriate), dominant and subdominant substrate classes, and percent fines to the recorder.

As the observer moves upstream through the unit, the recorder follows behind, recording the amount of LW in the habitat unit. The recorder also assigns a number to the habitat unit. The recorder tells the observer if a unit is designated for measurements (i.e. if it is a ‘paired sample’ unit) only after they have recorded visual estimates.

The crew continues upstream making estimates in every habitat unit and making estimates and measurements in every paired sample unit until the inventory endpoint is reached.

Definitions of habitat attributes, how to measure and when to record them, and what to do when the inventory is complete are covered in the following sections.

Section 2: Stream Attributes

Unit Type (see abbreviations)

Definitions:*

Unit Type	Abbreviation	Definition
Riffle	**R**	**Fast water, turbulent, gradient <12%**; shallow reaches characterized by water flowing over or around rough bed materials that break the surface during low flows; also **include rapids** (turbulent with intermittent whitewater, breaking waves, and exposed boulders), **chutes** (rapidly flowing water within narrow, steep slots of bedrock), and **sheets** (shallow water flowing over bedrock) if gradient <12%
Cascade	**C**	**Fast water, turbulent, gradient ≥12%**; highly turbulent series of short falls and small scour basins, with very rapid water movement; also **include sheets** (shallow water flowing over bedrock) and **chutes** (rapidly flowing water within narrow, steep slots of bedrock) if gradient ≥12%
Run	**RN**	**Fast water, non-turbulent, gradient <12%**; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile
Pool	**P**	**Slow water, surface turbulence may or may not be present, gradient <1%**; generally deeper and wider than habitat immediately upstream and downstream, concave bottom profile; **includes dammed pools, scour pools, and plunge pools**
Glide	**G**	**Slow water, no surface turbulence, gradient <1%**; shallow with little to no flow and flat bottom profile
Underground	**UNGR**	Stream channel is dry or not containing enough water to form distinguishable habitat units

*modified from Armantrout (1998)

How to estimate:
Habitat units are separated by 'breaks'. Breaks can be obvious physical barriers, such as a debris dam separating two pools or a small waterfall separating a pool and riffle, or may be less obvious transitional areas. Questions often arise as to whether a break is substantial enough to split two habitat units and where the exact location of the break occurs. When in doubt, the observer should consult with the recorder and the team should 'think like a fish'. To determine if a break should be made, consider whether a fish would have to make an effort to move across the break and into the next habitat unit. If not, then it is probably a single habitat unit.

The channel may have both pool and riffle type habitat in the same cross-sectional area. Determine the predominate habitat type and record it as the unit type. For example if an area contains both pool and riffle, but the majority of the flow is into and out of the pool habitat, then call a pool.

Questions also often arise as to the minimum size of individual habitat units. Generally, if a habitat unit is not at least as long as the wetted channel is wide, then do not count it as a separate habitat unit. This rule may need to be adjusted for streams wider than 5 m. Use best professional judgment in such cases.

See the section 2.1 for a list of features that should also be recorded while performing the inventory.

When to record: every habitat unit

Unit Number (#)

Definition:
Count of habitat units of similar types, used to determine location of paired sample units

How to estimate:
When counting habitat units, group pools and glides (slow water) together, and group riffles, runs, and cascades (fast water) together. For example, consider the following sequence of habitat units:

Pool – Riffle – Pool – Pool – Riffle - Cascade – Riffle - Glide – Riffle – Pool – Run – Pool – Riffle

Habitat units in this sequence would be counted in the following manner (similar types are shaded same color):

Unit Type	Unit Number
P	1
R	1
P	2
P	3
R	2
C	3
R	4
G	4
R	5
P	5
RN	6
P	6
R	7

In the above example, the crew has counted six slow water (pool/glide) units and seven fast water (riffle/run/cascade) units.

If '3' were chosen as the random number and the measuring interval was every 10^{th} unit, the crew would estimate and then measure habitat data for Pool 3 and Cascade 3 (i.e. Pool 3 and Cascade 3 are 'paired sample' units). When the crew reaches pool or glide 13 and riffle, run, or cascade 13, they would repeat procedures followed in the 3^{rd} units.

When to record: every habitat unit; not recorded for features such as falls, tributaries, side channels, culverts, etc.

Distance (m)

Definition:
Number of meters from the start of the inventory to the upstream end of the habitat unit or distance from the start of the inventory to upstream end of a feature, used as spatial reference for data analysis and to locate features in the future.

How to estimate:
The observer walks upstream in the middle of the stream channel with a hipchain measuring device. When they reach the upstream break between habitat units or the upstream end of a feature they stop and report the distance to the recorder.

Care should be taken to keep the hipchain string in the middle of the stream, especially around bends and meanders. If the hipchain should break, retreat to the location where the break occurred, tie off the hipchain, and continue. If the hipchain is reset for any reason be sure to note it in the comments.

When to record: every habitat unit and feature

Estimated Width (m)

Definition:
Average wetted width of the habitat unit as estimated visually, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to estimate:
The observer notes the general shape and width of the unit while walking to the upstream end. When they reach the upstream end of the unit the observer stops, turns to face the unit, and estimates the average wetted width. Measure the wetted width of the stream before starting each day to calibrate yourself.

When to record: every habitat unit

Maximum and Average Depth (cm)

Definitions:
Maximum Depth – vertical distance from substrate to water surface at deepest point in habitat unit
Average Depth – average vertical distance from substrate to water surface in habitat unit

How to estimate:
The observer uses a wading rod marked in 5 cm increments to measure water depth as they walk upstream through the habitat unit. Water depth in deepest spot is recorded as the maximum depth. Average depth is the average of several depth measurements taken throughout the habitat unit.

When to record: every habitat unit

Riffle Crest Depth (cm)

Definition:
Vertical distance from the substrate to the water surface at the deepest point in the riffle crest. The riffle crest is the shallowest continuous line (usually not straight) across the channel where the water surface becomes continuously riffled in the transition area between a riffle (or a run or cascade) and a pool (or glide) (Armantrout 1998); think of it as the last place water would flow out of the pool if the riffle ran dry.

How to estimate:
When the observer reaches the upstream end of a riffle (or a run or cascade) leading into a pool (or glide), they use the wading rod to measure the deepest point in the riffle crest. Record the depth in the RCD column for the riffle habitat row.

When to record: at the upstream end of any riffle, run, or cascade leading into a pool or glide; also record RCD where short riffles break pools

Dominant and Subdominant Substrate (1-9)

Definitions:

Dominant Substrate: size class of stream bed material that covers the greatest amount of surface area within the wetted channel of the habitat unit

Subdominant Substrate: size class of stream bed material that covers the 2nd greatest amount of surface area within the wetted channel of the habitat unit

How to estimate:

The following size classes are used to categorize substrates*. The substrate 'Number' is entered into the dominant and subdominant substrate columns on the datasheet.

Type	Number	Size (mm)	Description
Organic Matter	1		dead leaves, detritus, etc. – **not live plants**
Clay	2		sticky, holds form when rolled into a ball
Silt	3		slippery, does not hold form when rolled into a ball
Sand	4	silt – 2	grainy, does not hold form when rolled into ball
Small Gravel	5	3-16	sand to thumbnail
Large Gravel	6	17-64	thumbnail to fist
Cobble	7	65-256	fist to head
Boulder	8	>256	larger than head
Bedrock	9		solid rock, parent material, may extend into bank

** these size classes are based on the modified Wentworth scale*

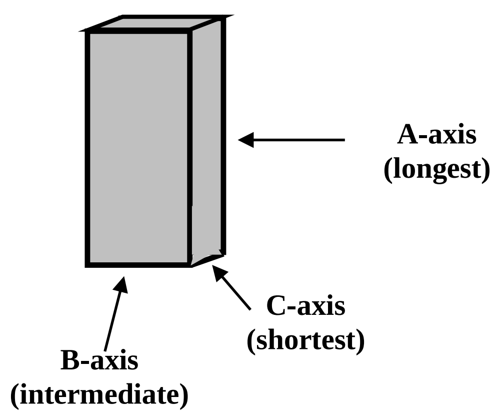
As the observer walks through the unit they scan the substrate. When they reach the upstream end of the unit they stop, turn to face the unit, and determine the dominant and subdominant substrate classes.

Estimate substrate size along the intermediate axis (b-axis). The b-axis is not the longest or shortest axis, but the intermediate length axis (see below). It is the axis that determines what size sieve the particle could pass through. Remember that your eyes are naturally drawn to larger size substrates. Be careful not to bias your estimate by focusing on the large size substrate.

Some units will contain a mixture of particle sizes. Consult with the recorder and use your best professional judgment to choose the dominant and subdominant sizes.

In units where the substrate is covered in moss, algae, or macrophytes classify the underlying substrate and make note of the plant growth in the comments. Only call organic substrate where there is dead and down leaves or other detritus covering the bottom of the unit.

When to record: every habitat unit



Percent Fines (%)

Definition:
Percent of the total surface area of the stream bed in the wetted area of the habitat unit that consists of sand, silt, or clay substrate particles (i.e. particles < 2 mm diameter).

How to estimate:
As the observer walks through the habitat unit they note the amount of sand, silt, and clay in the habitat unit. When they reach the upstream end of the unit, they stop, turn to face the unit and estimate the amount of the total surface area within the wetted channel that consists of sand, silt, or clay.

Where to estimate: every habitat unit

Large Wood (1-4 and rootwad)

Definition:
Count of dead and down wood within the bankfull channel of a habitat unit

How to estimate:
The recorder classifies and counts LW as they walk through the habitat unit. LW counts are grouped by the size classes listed below:

Category	Length (m)	Diameter (cm)	Description
1	1-5	10-55	short, skinny
2	1-5	>55	short, fat
3	>5	10-55	long, skinny
4	>5	>55	long, fat
RW	rootwad	rootwad	roots on dead and down tree

Only count large wood that is:
- > 1.0 m in length and > 10.0 cm in diameter
- within the bankfull channel
- fallen, not standing dead

- Count rootwads separately from attached pieces of LW
- Estimate the diameter of LW at the widest end of the piece
- A piece that is forked, but is still joined counts as only one piece of LW
- Only count each piece one time, do not count a piece that is in two habitat units twice
- Enter the total count for each size category into the appropriate column on the datasheet

Where to estimate: every habitat unit

Hemlock Large Wood

Definition:
Count of dead and down wood within the bankfull channel of a habitat unit that is identifiable as hemlock (Hemlock LW is already counted in LW Data; this is a separate count of only Hemlock LW, all size classes combined).

How to estimate:
The recorder counts a total tally of all LW that is identifiable as hemlock as they walk through the habitat unit. Only count hemlock large wood that is > 1.0 m in length and > 10.0 cm in diameter, within the bankfull channel, and fallen, not standing dead.

Actual Width (m)

Definition:
Average wetted width of the habitat unit as measured with 50 m tape, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to measure:
Use a meter tape to measure the wetted width of the stream in at least three locations. Average the measurements to obtain the average wetted width.

Where to measure: paired sample habitat units

Hemlock Condition

Definition:
Visual estimate of the condition of standing hemlock trees (DBH >10 cm) in the riparian zone (water's edge to 30 m up the streambank; visually estimated) as you walk between paired fast-water units. For the first paired sample, the condition of riparian hemlocks is since the start of the inventory.

How to measure:
Observe the general condition of hemlocks in the riparian area as you walk between paired sample units. Select from one of the following categories for hemlock condition:

Category	Description	Wooly needles	Needle loss	Limb loss
Healthy/Light Infestation (1)	Healthy or early stages of infestation	None to some	0-25%	Rare
Infested (2)	Late stages of infestation	Yes	25 – 75%	Small, medium branches
Dead (3)	Mortality; majority of hemlocks are dead	Yes for the few remaining needles	> 75%	Small, medium, large branches and tree tops

Where to measure: assess throughout reach, but record only at paired fast-water units

Hemlock Abundance

Definition:
Category describing the total number of hemlocks encountered since the last paired fast-water unit.

How to measure:
Estimate the number of standing hemlock trees (live or dead with DBH >10 cm) in the riparian zone (water's edge to 30 m up the streambank; visually estimated) as you walk between paired fast-water units.

Select from one of the following categories for hemlock abundance:
None (1) = no hemlocks; **Few (2)** = 1-10; **Some (3)** = 11-50; **Many (4)** = >50 hemlocks

Where to measure: do counts throughout reach but record only at paired sample habitat units

Photo #

Definition:
Photograph of habitat unit or crossing feature.

How to measure:
Take photo facing upstream with observer holding wading rod in picture. Be sure to get entire width (and length if possible) of habitat unit or crossing feature in the photo. Record photo number shown on digital camera.

Where to measure: paired sample riffles, runs, or cascades and any crossing features encountered

GPS (ID)

Definition:
Name of the point recorded to mark a waterfall, crossing feature or other location in the GPS unit.

How to measure:
Stand as close to the feature as possible and allow the GPS to have a clear view of the sky. Mark a waypoint on the GPS, then edit the waypoint name as follows:

S##	**Start** location of BVET survey
P##	**Pause** location of BVET survey if survey is not completed that day
T##	**Tributary** with name shown on quad map
E##	**End** location of BVET survey when survey is completed
W##b	**Waterfall**
B##b	**Bridge**
Fd##b	**Ford**
D##b	**Dam**
V##b	**Culvert**
O##b	**Other**, enter a brief description into the note section for the waypoint

= stream priority number – see stream list or map
b = use b, c, d, etc to create unique labels when more than 1 of a feature type are encountered on a stream; for example if 3 waterfalls are found on stream priority number 5 the first waterfall would be W5, the second would be W5b, the third W5c

Where to measure: all waterfalls, all crossing features, any other notable features encountered during the survey that we may want to locate in the future or that could serve as landmarks

See Section 5 below for additional information on GPS use.

Features

Definition: points on a stream that could potentially serve as landmarks, may be natural or manmade

How to measure: record the distance to the upstream end of a feature; record distance of **all features** (both stream and crossing features) in the regular habitat datasheet; also record additional measurements for crossing features in the crossing datasheet and take a photograph of all crossing features

Where to record: wherever found

Channel Feature	Abbreviation	What to Record
Waterfall[1]	**FALL**	Distance, estimated height
Tributary	**TRIB**	Distance, average wetted width, into main channel on left or right (as facing upstream)
Side channel[2]	**SCH**	Distance, average wetted width, whether it is flowing into or out of main channel on left or right (as facing upstream)
Braid[3]	**BRD**	Distance at start and distance at end; continue with normal inventory up channel with greatest discharge
Seep (Spring)	**SEEP**	Distance, left or right bank (as facing upstream), size, coloration
Landslide	**SLID**	Distance, left or right bank (as facing upstream), estimated size
Other	**OTR**	Distance, description of feature, *example:* found water intake pipe going to house here; old burned out shack on side of stream; Big Gap campground on left; alligator slide here, etc.

1 must be vertical with water falling through air to be a waterfall and not a cascade, do not record unless >1m high
2 two channels, continue with normal inventory up channel with most volume
3 three or more channels intertwined, continue with normal inventory up channel with most volume

Crossing Feature	Abbreviation	What to Record*
Bridge	**BRG**	Distance, width, height, road or trail name and type (gravel, paved, dirt, horse, ATV, etc.), photo
Ford	**FORD**	Distance, road or trail name and type (gravel, paved, dirt, etc.), photo
Dam	**DAM**	Distance, type, condition, estimated height, dam use, name of road or trail, if applicable; include beaver dams, photo
Culvert	**V**	Distance, road or trail name, type, # of outlets, diameter/width, height, material, perch (distance from top of water to bottom lip of culvert, natural substrate (present or absent through length), photo

* photograph all crossing features with person and wading rod for scale, record 'Y' in 'Photo' column

We cannot stress enough the importance of fully and accurately describing features. This means getting out a quadrangle map and finding road, trail, and tributary names and recording them in 'Comments' and taking the time to describe the location of features in relation to landmarks found on quadrangle maps.

Take photos of all crossing features and waterfalls!
Take GPS of all waterfalls!

Section 3: Wrapping Up

End the inventory where previous inventory ended or:

- Forest Service property ends
- Stream is dry for more than 500 m
- Stream channel is < 1.0 m wide for more than 500 m

Record the following in the Comments:

- Time and date
- Reason for ending the inventory
- Detailed written description of location using landmarks for reference
- **Be sure the header information is completed – GPS, etc**

When you return to home base:

- Immediately download the data and check file to be sure all data downloaded
- Check header information to be sure it is complete
- Save to the computer and create a backup copy
- Document any photographs
- If using paper, make a photocopy of the data and store in secure location

Section 4: Summary

Before starting:

- fill in header information

Record for every habitat unit:

- Unit Type
- Unit Number
- Distance
- Estimated Width
- Maximum Depth
- Average Depth
- Dominant Substrate
- Subdominant Substrate
- Percent Fines
- Large Wood and Hemlock LW

Record for every riffle, run, or cascade (including breaks) leading into a pool or glide:

- Riffle Crest Depth

Record for every paired sample pool:

- Measured Width

Record for every paired sample riffle:

- Measured Width
- Hemlock Condition and Abundance
- Photograph
- Water Temperature

Record features and full feature descriptions wherever they are encountered.

Photograph all crossings!

Section 5: GPS Instructions

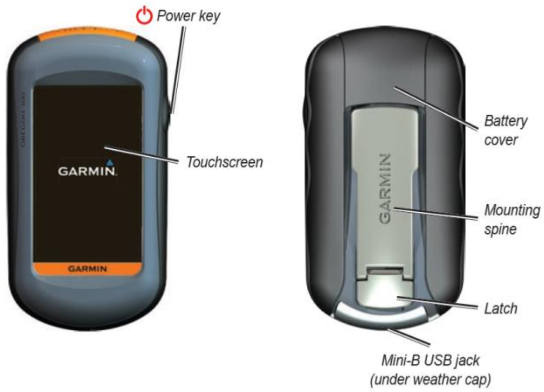
How to Find a Waypoint on GPS:

- Turn Power On.
- On the main menu screen touch the **Where To?** icon with the magnifying glass.
- Touch the **Waypoints** icon with the red golf flag.
- At the bottom of the next screen touch the **ABC** pyramid button.
- Start typing in the name of the desired waypoint. Once the waypoint name is identified by the GPS it will list the waypoints associated with that waypoint name.
    - Note: Touch the left and right arrows at the bottom of the screen to move from letters to numbers to symbols. Touch the down arrow on the letters to get lowercase and up arrow to get back to uppercase.
- Touch the waypoint name you were looking for when the list pops up.
- To navigate to this location touch the big green **Go** button.

Changing Waypoints:

- To switch waypoints close the map screen by touching the **X** close button in the lower left corner of the screen.
- On the main menu screen touch the **Where To?** icon with the magnifying glass.
- Touch the Stop Navigation button and repeat the top process to get to a new waypoint.

Garmin GPS Oregon 400T Cheatsheet



Turn On

- Press Power key, wait for GPS to boot

Turn Off

- Press and hold Power key

Backlight Strength

- Press and quickly release Power key, adjust with touchscreen options

Create New Waypoint

1. To create a waypoint of your current position touch "*Mark Waypoint*"
2. Touch "*Save and Edit*", touch "*Change Name*", type desired label, touch "*Green Check Icon*" to save

Calibrate compass

1. Whenever batteries are removed you must calibrate the compass so the map orients correctly
2. Touch "*Setup*", touch "*Heading*", touch "*Press to Begin Compass Calibration*"
3. Touch "*Start*", hold GPS level and rotate it twice on your palm

Data Fields

1. To change the data fields on the map page touch "*Map*"
2. Touch a data field at the top of the map, then select your desired data field

Calibrating the Touchscreen

1. If the touchscreen buttons are not responding properly, recalibrate the touchscreen
2. While the GPS is turned off, press and hold the power key for ~30 seconds
3. Follow instructions on the screen until calibration is complete

Appendix: Field Guide, Random Numbers Table, Equipment Checklist

Record for every habitat unit:
Unit Type: pool, riffle, run, cascade, glide, feature (see below)
Unit Number: group pools & glides; group riffles, runs, cascades
Distance: (m) at upstream end of unit
Estimated Width: (m) visual estimate of average wetted width
Maximum Depth: (cm) deepest spot in unit
Average Depth: (cm) average depth of unit
Dominant Substrate: (1-9) covers greatest amount of surface area in unit
Subdominant Substrate: (1-9) covers 2nd most surface area in unit
Percent Fines: (%) percent of bottom consisting of sand, silt, or clay
Large Wood: (1-4, RW) count of dead and down wood in the bankfull channel
Hemlock Large Wood: count of dead and down Hemlock wood in the bankfull channel

Record for every riffle, run, or cascade leading into a pool or glide:
Riffle Crest Depth: (cm) deepest spot in hydraulic control between riffle type habitat and pool type habitat

Record for paired sample pools:
Measured Width: (m) measurement of average wetted width

Measured Width: (m) measurement of average wetted width
Hemlock Abun.: 1 None, 2 Few =1-10, 3 Some=1-50, 4 Many=>50
Hemlock Condition: 1 Healthy, 2 Infested, 3 Dead
Water Temperature: C, place thermometer in shaded area
Photo # : picture of habitat unit or crossing feature

Record for paired sample riffles:

Unit Types
Riffle (R) fast water, turbulent, gradient <12%; includes rapids, chutes, and sheets if gradient <12%
Cascade (C) fast water, turbulent, gradient ≥12%, includes sheets and chutes if gradient ≥12%
Run (RN) fast water, little to no turbulence, gradient <12%, flat bottom profile, deeper than riffles
Pool (P) slow water, may or may not be turbulent, gradient <1%, includes dammed, scour, and plunge pools
Glide (G) slow water, no surface turbulence, gradient <1%, shallow with little flow and flat bottom profile
Underground (UNGR) distance at upstream end, why dry

Features
Waterfall (FALL) distance, height, GPS
Tributary (TRIB) distance, width, in on L or R
Side Channel (SCH) distance, width, in or out on L or R
Braid (BRD) distance at downstream and upstream ends
Seep or Spring (SEEP) distance, on left or right, amount of flow
Landslide (SLID) distance, L or R, est. size and cause
Other (OTR) record distance, describe feature in comments
Crossing Features: Photograph and record the following:
Bridge (BRG) distance, height, width, road or trail name & type
Dam (DAM) distance, type, est. height, road or trail name &type
Ford (FORD) distance, road or trail name & type
Culvert (V) distance, type (pipe, box, open box, arch, open arch), size, material, natural substrate, perch (top of water to culvert) road or trail name

Substrates
1. **Organic Matter**, dead leaves detritus, etc., not living plants
2. **Clay**, sticky, holds form when balled
3. **Silt**, slick, does not hold form when balled
4. **Sand**, >silt-2mm, gritty, doesn't hold form
5. **Small Gravel**,3-16mm, sand to thumbnail
6. **Large Gravel**, 17-64mm, thumbnail to fist
7. **Cobble**, 65-256mm, fist to head
8. **Boulder**, >256, > head
9. **Bedrock**, solid parent material

Large Wood
1. <5m long, 10-55cm diameter
2. <5m long, >55cm diameter
3. >5m long, 10-55cm diameter
4. >5m long, >55cm diameter

RW: rootwad – count separately from attached LW, record in comments
do not record woody debris <10cm diameter, <1m length

End inventory
Where stream is less than 1.0 m wide for > 500 m, or channel runs dry for > 500 m, or where boundary is reached. Comment on why inventory was ended. Record time of day, detailed description of location, and GPS coordinates at endpoint, and be sure all header info is filled in on datasheets.

Random numbers for measuring every 5th unit

4	3	5	1	5	1	2	5	2	3
2	5	2	5	2	2	1	5	4	1
3	2	5	1	2	1	3	1	5	3
5	4	1	5	1	3	5	4	2	5
4	2	2	5	2	2	5	5	2	1
4	2	5	2	2	4	5	5	5	2
3	5	4	1	5	1	4	1	3	3
1	4	2	2	1	4	3	1	5	3
5	4	3	3	2	4	1	2	5	1
4	4	1	1	3	5	1	5	5	4

Random numbers for measuring every 10th unit

3	7	10	5	1	2	2	7	10	6
4	2	3	8	9	2	4	4	6	9
3	3	8	4	3	9	9	7	5	5
1	3	5	5	2	6	5	2	2	6
3	7	8	6	3	8	8	5	2	10
10	9	6	9	4	3	10	7	2	10
6	10	5	4	8	10	4	1	4	10
4	3	4	3	2	3	4	4	3	7
5	1	7	9	7	3	10	7	10	3
9	6	8	6	2	2	1	9	10	5

Choose a new random number at the beginning of each stream inventory
Use the number for the entire stream
Use the first table for streams < 1.0 km long, the second table for streams >1.0 km long

Equipment Checklist

- [ ] hipchain
- [ ] extra string for hipchain
- [ ] wading rod
- [ ] 50 m tape measure
- [ ] clinometer
- [ ] thermometer
- [ ] iPad
- [ ] handheld GPS unit
- [ ] camera
- [ ] backpack
- [ ] pencils
- [ ] flagging
- [ ] markers
- [ ] waterproof backup datasheets
- [ ] clipboard
- [ ] BVET field guide on waterproof paper
- [ ] topographic maps
- [ ] water
- [ ] water filter
- [ ] lunch
- [ ] first aid kit
- [ ] radio/cell phone
- [ ] toilet paper
- [ ] non-slip wading boots
- [ ] raingear

Remember the following for the start of each new stream or reach:

- Determine measuring interval
- Select a random number
- Fill in header information completely